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An evaluation of a workbook method of instruction in engineering drawing for high school pupils.

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BY

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THE INTRODUCTION

Chapter I

The Introduction

Education may always have been at least indirectly a vocational enterprise but in recent years our schools have become more and more directly involved in the business of making a living.

1. The beginning of vocational education in the secondary schools. -- During the later years of the nineteenth century a comparatively new subject was being cautiously offered in the secondary schools of the nation. Although it was given a number of titles it was most commonly called manual training because most academic educators thought of it and spoke of it as education through hand manipulation.[1]

Courses in early manual training in high schools of America consisted usually of a number of hand made joints used in cabinet making, a small project in wood to make a practical use of the exercises, and enough mechanical drawing to be able to create the project from an orthographic reproduction.

Neither vocational nor manual training was really new in either Europe or America at this time for the guild and burgh schools of the Middle Ages conducted classes to train boys in the secrets of crafts and related information. It

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(1) Lull, Secondary Education, Chapter V, pp. 61-62

had been almost a century since the great educator, Pestalozzi, maintained that schools should be equipped to rehabilitate the town waifs and provide such instruction that every one might be able to make a living with his hands. Then, too, there had been the successful Fellenberg School at Hofwyl, the curriculum and hours of study of which seemed not greatly different from a modern agricultural and mechanic arts university. While fortunate young adults were studying in technical schools, as in the Fellenberg School, fortunate youngsters attended the elementary and kindergarten schools of Hebart, Froebbel, and Oberlin who believed that learning required the use of hands as well as eyes and ears.[2]

Such training was not unique to Europe in these early years for we find recorded in the history of American education information regarding the trade schools of the Moravians in the 1700's, the John Owen's school at New Harmony, the Andover Seminary, the Oneida Institute, the Watertown, Wisconsin kindergarten and others.

For several possible reasons industrial training was omitted from the curriculum of the secondary schools except in the case of vocational schools.[3] To include man-

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(2) Sears, Roots of Vocational Education, Part II, pages 65-128.

(3) Lull, Secondary Education, page 62.

ual education of a technical nature in the curriculum of the high schools of the nation is comparatively new. Experiments using the Scandinavian sloyd had been tried in a few schools, but the real beginning in this field is usually associated with Dr. John Runkel of Massachusetts Institute of Technology. The Institute, which was then a secondary school preparing pupils for advanced schools of engineering, had been groping for methods and subject material. Dr. Runkel discovered a display by the Russian Imperial Institute at the Centennial Exposition in 1876 which he believed usable by his pupils. He immediately put the projects into practice. Three years later Professor Calvin Woodward of Washington University, St. Louis, expanded Dr. Runkel's plans and created the Manual Training High School.[4] Although the information taught today is much different than in Professor Woodward's Manual Training School, general industrial training is still considered the field of the high schools and specific industrial training is the job of the vocational schools. As may be expected there is much overlapping in the teaching of the two institutions.

2. Present day vocational and industrial education. -- Our present day vocational or trade schools vary more in method of instruction, equipment and courses offered than in the purpose of trade schools of other years. National

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(4) Mays, The Problem of Industrial Education, page 191.

financial aid, the break down of the apprentice system, and the rapidly changing industrial methods and conditions have caused modern schools to flourish.

Likewise, the manual arts department of the secondary schools no longer make exercises simply to coordinate the eye, muscle, and mind, but have changed to a study of industrial methods in general, which correlate with mathematics, science, and other academic subjects.

The elementary and junior high schools have retained to some extent, of course, the disciplinary type of training but are preparing pupils for the senior high schools with related information about industry in the way of moving pictures, trips, oral discussion and the practice of many fundamental tool processes.

Where the manual training of the high schools of 1900-20 consisted of woodwork and enough drafting to recognize views, courses of the 1930's offered patternmaking, foundry, machine shop practice, sheetmetal work, cabinet and millwork, metallurgy, heat treatment, printing and press work, electrical wiring, motor and generator construction, electronics, radio, internal combustion engines, auto mechanics, aeronautics, ceramics together with the necessary classes of drafting in order to interpret or express such information. Drawing classes may consist of machine drafting, architectural, sheetmetal, electrical and tool drafting. More classes will likely be added such as, airplane lofting, aeronautical design or welding drafting as the drafting in these phases of industry becomes standardized in convention or reduced to more practical rather than experimental bases.

Not all schools can attempt to teach all these subjects. The larger technical high schools may teach many of them while the smaller schools and the comprehensive schools try to cover as many of them as curriculum, time, public demand, and other factors allow by so-called "general" and "experimental laboratory" courses in various combinations.

With the apprentice system left to the larger industrial plants and systems to keep up a nucleus of company personnel, the preparation of the great bulk of both skilled and semiskilled workmen or women will fall on the public school system.

3. Mechanical drawing or drafting a part of vocational and industrial education. -- The vocational and industrial educational program is either specific for the individual that feels he has chosen an occupation or, general for the individual who may still be searching for his life's work.[5] Specific or general, if any of these occupations happen to be mechanical, structural or scientific trades the student must learn a specialized picture language known commonly as the "blueprint". It

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(5) Ashley, "Interrelationships of Industrial Arts and Vocational Education", Ind. Arts and Voc. Ed. Mag.,XXXI (January, 1942) page 4.

is, therefore, necessary that a careful study of this picture language be made for the mastery of any of these courses.

4. Orthographic drawing is universally accepted as a means of expression in many common industries. -- Drafting is almost a universal language in the industrial world. Each trade has its own special practices for convenience or idiosyncrasies according to development. For instance, architectural drawing retains some of the artistic touch of the drafting of a century ago while tool and machine drafting is bold, modern and masculine. Machine drafting is complete and with much detail, but sheetmetal drafting omits views and violates rules of standard practice in order to obtain the most accurate pattern in the shortest time in the easiest way. Yet, with all this necessary variation and conventionalization it is interesting to notice the slight amount of variation of drafting practices in other countries.[6]

5. Methods for teaching drafting and blueprint reading. -- Methods for teaching drafting and blueprint reading vary with each instructor and with each school.[7] One can learn to read with some proficiency the prints from a drafting room by study, reference and practice. It

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(6) Rigast, "Significance of Foreign Production Drawings in the Drawing Room", Ind. Arts and Voc. Ed. Mag. XXIX (June, 1940) page 229

(7) Hoelscher, Teaching Mechanical Drawing, pp. 14-16

is doubtful, however, if the results are as satisfactory as when taught from the draftsman's point of view. For this reason most of the pupils in secondary schools and engineering colleges are given instruction in reading prints by actually doing drafting.

A beginning course in drafting is generally an introductory course illustrating the common lines, views, dimensions and styles of lettering. This "tool" course is followed with information regarding fundamentals of projection and finally, special information for a particular trade, usually machine practice or domestic architecture, since they are the two most common branches using mechanical drawing. If the unit on fundamentals does not appear as a separate study, then it must appear in conjunction with other parts of the course.

The fundamental unit usually consists of a study of the position of points and lines of an object when projected on the horizontal, vertical and profile planes. This is similar to part of the study of descriptive geometry except the views are usually drawn in the third quadrant. The objects range from simple geometric solids to complex parts of industrial machines. Such a course may include projections onto auxiliary planes, determination of the lines of intersection between flat and curved surfaces, and development of the true shapes of surfaces.

6. Fundamentals of projection are often difficult to teach and understand. -- It seems to take considerable

effort on the part of many pupils to imagine the projection of an outline of an object onto certain geometrical planes, and then further imagine that these planes are revolved in a precise order to lie on the paper tacked to the board. Some of these projections require considerable mental and mechanical maneuvering before location is determined. One of the most difficult problems seems to be the determination of true lengths of edges that are not parallel to any of the planes of projection. These conditions may be due to an instructor's inability to create the proper trend of imagination in the pupils' minds and the pupils' inability to exercise their imaginative powers sufficiently. It would seem that repetition, properly directed, and in sufficient quantity would be a definite help through these mental and mechanical processes.

With the need for more and more experience in industrial information the fundamentals as exercises have been crowded out, and incorporated with practical problems which take more time to complete. Although this telescoping is necessary; there may be ways and means of teaching the information and still have time for the practice of basic facts if the less essential, time-consuming elements are reduced.

7. Reasons for using the workbook course. -- One possible method to accomplish this job of providing more actual trade information and giving a wider range of

experiences when class periods are not increased in length, is by supplying the pupil with material which has been previously prepared in such a way that unimportant factors will not absorb time.

For example, if pupils have learned how to make borders and title-boxes, some time may be saved by the use of printed sheets similar to those used by most industrial organizations. Likewise, if the "given part" of the problem is cleverly supplied, ready to be completed, considerable time is saved in plotting or copying. Similar devices called "workbooks" have been used in mathematics and science courses with satisfaction. With some special adaptation the same principles may be used in classes of drafting. Other instructors have given the plan thought, for there are on the market complete courses in drafting laid out in workbook form.[8]

The present study seeks to determine if a method which supplies problems set up for completion has any noticeable benefits or weaknesses in the learning of drafting procedure.

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(8) Williams, E. L. and Spencer, Henry C., Technical Drawing Problems.

French, Thos. and McCully, H. M., Engineering Drawing Sheets.

METHODS COMMONLY USED FOR TEACHING ADVANCED FUNDAMENTALS OF PROJECTION IN DRAFTING

Chapter II

Methods Commonly Used for Teaching Advanced Fundamentals of Projection in Drafting.

Mechanical drawing or drafting is taught according to several methods in the Senior High Schools, depending on the controlling philosophy in the curriculum and also upon the planning of the curriculum itself.

1. Drafting taught for informational values. -- In systems where the Senior High School has an "expanded phase" of vocational try-out courses drafting is usually taught as a general subject or as a unit in a general course of industrial subjects. That is, a course that might be called "Industrial Education" or "Practical Arts" might consist of nine weeks of drafting, nine weeks of metalwork, nine weeks of woodwork and nine weeks of electrical work.[1] In some schools drafting itself is taught as a general course. Pupils are required to draw problems of architectural, aeronautical, electrical, mechanical or structural nature, learning the fundamentals along with the special conventions of each type. This method has been adopted in the Junior High Schools more than in the Senior High School grades.[2]

The Industrial Arts Laboratory curriculum considers drafting more as a means to the achievement of problems or experiments than as a course in itself. A special area or

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(1) Newkirk and Stoddard, The General Shop, pp. 11-43

(2) McGee and Sturtevant, General Mechanical Drawing.

glazed room is equipped so that pupils may plan a problem or experiment. The teacher is expected to supply suggestions and help, but is not expected to teach more information than is needed to complete the job.[3]

2. Teaching drafting for mastery in reading and execution. -- Drafting was probably introduced into the secondary school curriculum as an auxiliary to the shop classes, but graduated into a subject unit when industrial educational leaders deemed it necessary to master the fundamentals in order to be able to read orthographic drawing accurately and develop youth for a technical education or for the industrial field of occupation.

Many of the schools in the industrial areas of the nation where high schools must prepare a large percentage of their pupils in an industrial field have adopted the type of drafting course that tends toward proficiency in reading or making one or more of the types of industrial drawing.

There seem to be three general methods of procedure in an attempt to complete this mastery of the subject of drafting. The simplest method is to follow the course outlined in a special text where one project progresses to the next in what the author believes to be the best psychological and most practical order. In nearly

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(3) Warner, "Establishing the General Shop", Ind. Arts and Voc. Ed. Magazine, Vol. XIX, (August 1930)

every text the course teaches the basic fundamental features of third angle orthographics by using simple geometrical shapes or blocks gradually approaching simple mechanical parts up to the point where it seems probable that mastery of these facts has been achieved by the average individual. The author then returns to his blocks and geometrical shapes and advances more facts about drawing by projection by revolving the object out of its normal position, calling attention to lines that are true-length, development of the true shapes of surfaces and projection onto auxiliary planes somewhat as is done in descriptive geometry. Parallel and radial development problems allow the motivation of interest by incorporating practical information in sheet-metal drafting.[4] One author makes his explanations of projection lines in certain planes and piercing points of elements by the picturesque comparisons of soldiers shooting at oblique targets and rain drops striking a tent roof so that he is able to arrive at rules to use under certain conditions.[5] The pupil's response to such a course is a series of problems drawn with the help of the instructor and the reference material.

Probably more common than justifiable is the course made up by the instructors of the drafting department.

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(4) Berg and Kronquist, The Essentials of Mechanical Drawing

(5) Emerling, Fisher & Greene, Mechanical Drawing, Part II, pp. 10-28

Such courses are usually built upon the teachers' conceptions of what is valuable and what is the best method of procedure. A text may or may not be used. Pupils make drawings of objects, real or imagined, supplied by the teacher. Related information may be supplied by books and demonstrations. Some of the best texts on the subject of drafting are developed for this type of course. Such books usually deal with each phase of drawing rather completely by chapter; the learning procedure being left to the curriculum, the teacher and and the pupil.

Mechanical drawing courses are also developed by correlation with shop, mathematics, and other secondary school subjects. It is the most difficult method of developing a teachable course, but usually the most satisfactory when carefully done. Teaching units of drafting are fairly well defined and can be made to parallel shop, mathematics and other kindred subjects if the instructors of these subjects will organize their courses to a more definite time table. The advanced basic fundamentals in this method of instruction may be withheld until pupils do sheetmetal work or geometry or may be sandwiched between shop problems since the drafting of a problem takes much less time than actual construction.

3. Special pedagogical practices used in the teaching of fundamentals in drafting. -- There are many

devices used by various instructors to help pupils understand the theory and methods of construction of orthographic drawing. Nearly all instructors use the blackboard with gadgets to simulate drafting tools. Colored chalk is used effectively to show steps in development or lines of projection. Hinged plastic sheets are used to represent the coordinate planes and profile plane. Models of wood, sheetmetal, paper and plastics are exceedingly helpful.[6] Reflectoscopes are valuable aids because they can be used to project pupil work directly onto a translucent screen for constructive criticism. By proper drafting the stereoptican idea has been used to bring out the idea of a third dimension.[7] Mirrors and geared mechanical devices that automatically revolve the object into proper position are used by some instructors to demonstrate views, true-length lines, visibility of edges and positions best for auxiliaries.[8]

While all of these methods and gadgets are valuable teaching agencies there may be other important

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(6) Newton, "Transparent Models in Teaching Drafting", _School Shop_, I, (April 1939), p. 18

(7) Rule, "Stereoscopic Drawing as an Aid to Visualization", _Mechanical Drawing News_, III, (April 1939) p.5

(8) Grant, "An Orthographic Projection Device", _Mechanical Drawing News_, III, (April 1939) p.9

means of saving time in order to allow repetition enough for mastery of the unit.

4. <u>The workbook method as a teaching device in mechanical drawing</u>. -- Workbooks are used to set up practice problems in definite forms in academic and shop subjects. In mechanical drawing the workbook has a similar purpose, but must be made with loose leaves in order to be tacked to the drawing board. On each sheet made of drawing paper or tracing paper are printed the border lines and blank title box as found in professional drafting rooms. However, there is usually added a problem in some stage of completion with necessary instructional information in the form of a picture, diagram or written detail.

Such a method saves time in plotting, border layout and some lettering. Not only is there an actual saving of time in drawing, but also, time in giving instruction and demonstration, if the steps and sheets are well organized. It is probable that there are other advantages in that there would be no errors due to improper layout and less discouragement due to preliminary work if a plate needs to be repeated. It is this workbook type of a device which the author believes has merit and wishes to evaluate.

ANALYSIS OF PROCEDURE

Chapter III

The Analysis of Procedure

The purpose of this study was to determine the effect of increasing the amount of repetition in mechanical drawing by using especially prepared drawing plates which allow more than the normal number of problem solutions.

1. The problem. -- To determine the relative value of two methods of teaching advanced fundamentals of projection and pattern development in engineering drafting for high school pupils.

2. The school. -- The Springfield Technical High School afforded an excellent opportunity to make such a study because every boy in the 11B class is required to study this unit of drafting. This group is about 300 in number and consists of boys in College Preparatory and General courses. They would, therefore, represent a normal cross-section of high school boys of that age, unless they are slightly more mechanical in interest as a group, because a number of the boys from the city choose to go to the High School of Commerce, Classical High School or Cathedral High School in search of classes more to their interest.

3. Subjects.-- The author arranged to be assigned four classes during one semester making a group of about 130 pupils. Two of the classes, periods 1 and 2, were allowed to carry on the traditional course as a control group.

The other two classes, periods 3 and 5, were the experimental group.

4. <u>The procedure</u>. -- The steps in conducting this experiment were as follows:

a. Preparation of materials. -- <u>Control group</u> -- 70 pupils. A bulletin of prints is issued to each pupil with drawing paper as needed.[1] The print consists of a problem drawn to a smaller scale partially completed. <u>Experimental group</u>-- 58 pupils. The material for the experimental group consisted of 40 sheets of drawing paper upon which were printed problems partially completed, similiar to the prints supplied to the control group, but at full scale so that the pupil could continue the problem to completion.[2]

b. Pairing of pupils. -- In order to get equal sized groups of comparatively equal abilities pupils of the control group were paired with pupils of the experimental group. The pairing of pupils was made on the basis of

(1) Intelligence quotient -- Henmon-Nelson

(2) English grades -- 10th year

(3) Mathematics grades -- 10th year

(4) Shop grades -- 10th year woodwork

(5) Mechanical drawing -- 10th year

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(1) Appendix No. 1

(2) Appendix No. 4

(See Chapter IV for details)

c. Administering the preliminary test. -- The test was a group of six tests consisting of:

(1) Statements regarding terms and tools

(2) Recognition of terms for parts of drawings

(3) Recognition of views and developments

(4) Location of positions of points and lines

(5) Drawing of a problem

(6) Technique

These tests were made by the author since no standard tests can be obtained which are constructed solely for this particular field of drawing. A set of the tests is shown in Appendices Nos. 6 to 11 inclusive.

d. Teaching the groups. -- After administering the group of preliminary tests the two groups progressed in their courses for 16 weeks, the control group following the normal method, the experimental group with the special workbook method. All groups were taught by the author.

e. Administering the final test. -- The final test was the same group of tests as the preliminary test and given under as similar conditions as possible.

f. Determination of the gains. -- The scores of the final tests were compared with those of the preliminary tests, both in its entirety and by parts, according to accepted statistical methods to determine the reliability of the results.

THE SELECTION

AND VARIATION OF THE GROUPS

Chapter IV

The Selection and Variation of the Groups

In order to obtain two groups as equal in ability as possible, boys in the classes in which the traditional courses were conducted were paired with boys in the experimental classes according to similarity of I.Q. and certain subject grades during their tenth grade year.

1. Method of pairing pupils. -- Data was collected from the office files for each pupil in the two groups, control and experimental, regarding I.Q., English, mathematics, shop work and mechanical drawing grades for the tenth year. There were forty boys in the experimental group that were found to have co-partners in the control group with similar characteristics in I.Q. and the above mentioned subjects. Of the original group of forty pairs subsequent drop-outs caused a loss of eight pairs, so that the results of the experiment are based on the attainment of these final thirty-two pairs.

2. Reasons for selecting certain subject grades and I. Q. as a basis for pairing pupils. -- It has become customary to assume that the Intelligence Quotient is the best unit for predicting success in school work. However, since success in drafting may require other factors, the grades of other subjects were included. English grades were included because a certain amount of oral and written directions must be given. Drafting is to a large

extent a practical use of geometry, and shop work should be somewhat indicative of mechanical ability; therefore these last two grades were included. As important as any of the grades was the tenth year drafting grade.

3. Results of pairing for Intelligence Quotient.-- Table I (page 26) shows the comparison of the groups according to the Intelligence Quotient obtained from the Henmon-Nelson Tests.

With average I.Q.'s of 117.8 and 116.6 and standard deviations of 11.58 and 11.74 respectively, the indications are that in both central tendency and dispersion the groups are sufficiently similar in I. Q. for this study.

4. Results of pairing for English grades. -- Table II (page 27) shows the comparison of the same pupils as in Table I according to the English grades received for the tenth year or the first year in Senior High School.

The comparison of the control and experimental groups in English show an average of 3.59 and 3.43 and a standard deviation of 1.24 and 1.99 respectively. This indicates a slight advantage for the control group since the experimental group is somewhat more heterogeneous.

Table I

Comparison of the Control and Experimental Groups by I. Q.

I. Q.	Control Group Pupils	Experimental Group Pupils
145-149	1	0
140-	1	1
135-	2	1
130-	0	2
125-	3	2
120-	1	2
115-	6	5
110-	7	8
105-	3	3
100-	1	1
95-	2	2
Total	27	27

Mean I. Q. for Control Group	117.8	Mean I. Q. for Experimental Group	116.6
Standard Deviation	11.58	Standard Deviation	11.74

Table II

Comparison of the Groups by English Grades

Grades	Control Group Pupils	Experimental Group Pupils
6.0-6.4	1	0
5.5-	0	2
5.0-	3	3
4.5-	3	3
4.0-	3	2
3.5-	5	2
3.0-	8	8
2.5-	4	10
2.0-	5	4
1.5-	0	0
1.0-	1	0
Total	32	32

Mean Grade for Control Group	3.59	Mean Grade for Experimental Group	3.43
Standard Deviation	1.24	Standard Deviation	1.99

5. Results in pairing for mathematics grades. -- The following table shows the comparison of the two groups according to the grades awarded in mathematics during the first year in Senior High School.

Table III

Comparison of the Groups by Mathematics Grades

Grades	Control Group Pupils	Experimental Group Pupils
6.0-6.4	1	1
5.5-	1	1
5.0-	2	0
4.5-	1	1
4.0-	6	7
3.5-	2	0
3.0-	8	11
2.5-	1	3
2.0-	8	6
1.5-	1	1
1.0-	1	0
Total	32	32

Mean Grade for Control Group	3.44	Mean Grade for Experimental Group	3.36
Standard Deviation	1.20	Standard Deviation	1.05

Table III indicates the control and experimental groups are very nearly equal with averages of 3.44 and 3.36 respectively. Again the advantage is to the control group. The standard deviations of 1.20 and 1.05 indicate the experimental group is less heterogenous.

6. <u>Results of comparing the groups according to shop grades</u>. -- Table IV indicates the results of comparing the shop grades for woodwork during the 10th year.

<u>Table IV</u>

Comparison of the Groups by Shop Grades

Grades	Control Group Pupils	Experimental Group Pupils
6.0-6.4	0	0
5.5-	0	1
5.0-	3	2
4.5-	2	1
4.0-	11	6
3.5-	2	7
3.0-	9	9
2.5-	2	5
2.0-	3	1
Total	32	32

Mean Grade for Control Group	3.77	Mean Grade for Experimental Group	3.46
Standard Deviation	.84	Standard Deviation	.63

As in the Intelligence Quotient and the academic subjects the average shop grades indicate close similarity with some slight advantage shown in favor of the control group.

7. <u>Results from pairing pupils for drafting</u>. -- The freshman year grades for mechanical drawing are shown in Table V.

<u>Table V</u>

Comparison of the Groups by Drafting Grades

Grades	Control Group Pupils	Experimental Group Pupils
6.0-6.4	2	5
5.5-	0	0
5.0-	4	2
4.5-	2	1
4.0-	4	8
3.5-	5	4
3.0-	12	8
2.5-	1	1
2.0-	1	3
1.5-	1	0
Total	32	32

Mean Grade for Control Group	3.96	Mean Grade for Experimental Group	4.09
Standard Deviation	1.02	Standard Deviation	1.18

Again one may observe close similarity in central tendency for both groups, with the advantage, if any, for the experimental group. The experimental group, due apparently to a very few pupils with good grades, shows a greater standard deviation.

8. Summary of the results of the preceding tables.-- In order to get a better conception of the results of the pairing of pupils in the two groups a summary was made of the averages and standard deviations.

Table VI

A Summary of the Comparison of the Means and Standard Deviations of the Groups by I.Q. and Subject.

	Means		Standard Deviation	
	Control	Exper.	Control	Exper.
I. Q.	117.8	116.6	11.58	11.74
English	3.59	3.43	1.24	1.99
Mathematics	3.44	3.36	1.20	1.05
Shop Work	3.77	3.46	.84	.63
Drafting	3.96	4.09	1.02	1.18

These tables indicated that the groups were very similar in the abilities which would seem to have effect on the learning of drafting practice and interpretation of industrial drawing. Any small difference that does appear would seem to favor the control group.

9. Summary of Control. --

a. The preceding tables show the control and experimental groups sufficiently alike in abilities to be compared in an experimental study of this kind.

b. The same teacher acted as instructor for both control and experimental groups.

c. All pupils were boys in the 11B class at Technical High School. Advanced fundamental projection is required of all boys in the school. The two groups were made up of two sections each. The two control sections appeared in periods 1 and 2 daily and the two experimental sections appeared in periods 3 and 5 daily. The fifth period experimental class was considered to have had a disadvantage because it met immediately after a lunch recess, but the first period control class likewise met after a 25 minute "organization period" which was often infringed upon by overtime programs.

d. Each section had an instruction period of 43 minutes in mechanical drawing daily during the school week. The experiment ran for 16 weeks, not counting holidays, of the first semester of the 1941-42 school year.

e. It would appear that everything possible was arranged so that neither group would have a particular advantage.

PRESENTATION OF THE RESULTS OF THE EXPERIMENT

Chapter V

Presentation of the Results of the Experiment

The steps in conducting the experiment consisted of administering a test, teaching both groups according to plan and finally re-administering the same test. The results of the tests were then used in making mathematical comparisons according to acceptable statistical methods.

1. Making the achievement test. -- No achievement tests could be found that dealt entirely with the fundamentals of projection, so that it seemed necessary to construct the tests for this experiment. The tests were divided into six parts according to material and grouped so that they would be convenient to administer to classes in thirty-five minute periods.

Table VII (page 35) indicates generally the form of the battery of tests. Samples of the tests are shown in the Appendices Nos. 6 to 11 inclusive.

2. Administering the tests. -- The tests were administered on four consecutive days. Tests 1, 2, and 3 were given the first day. Part 4 was given the second day, part 5, the third and part 6 on the fourth day. General directions and information was memorized by the administrator so that all classes would have the exact amount of specification and type of introduction. Rigid time limits were held for each part.

Table VII

A Battery of Tests to Determine Achievement in Drafting

Test	Information	Form of	Type	Time	Total Pts.
#1	Tools--terms	Statements	Match	7 min.	10
#2	" "	Illustration	"	7 "	10
#3	Views and developments	Drawings	"	10 "	15
#4	Position of points-lines	Drawing	"	20 "	30
#5	Creating views-pattern	Picture of object	Draw'g	35 "	46
#6	Technique	Technical Sketch	"	35 "	12

3. Application of the material. -- The control and experimental groups progressed according to the plan as stated in Chapter 3. Because one week was lost at the beginning of the course due to testing and another at the end for the same reason, the control sections did not complete the usual number of plates but the classes were normal in other respects. The experimental group, likewise, could not be expected to complete the course laid out for them. The median pupil completed thirty-two plates and if they could have had the other eight days used for testing they would have completed three to five more. Actually the range of finished

plates varied from 23 to 40 (complete). In the control group the range was from 0 to 15. There were 16 plates in the control group course.

4. Final testing. -- During the sixteenth week of the experiment the tests given the first week were re-administered. There had been 69 school days of instruction and 112 calendar days from the time the last pretest was given until the first final test was administered. The same length of time and the exact oral directions were used for the final tests as for the preliminary tests. The parts of the final test were administered on the same day of the week as the pretests and were, therefore, in the same order.

A questionnaire was added at the end of the semester to determine the attitude of the pupils toward the experimental course.

5. Results of the tests as a whole. -- The results of the test in its entirety will be considered first and then its parts. The scores listed in the following tables indicate gain not actual score.

Table VIII (page 37) indicates there has been more gain in the experimental group than in the control group. There seems to be more variability in the experimental group, but the same fact appeared in the grades of the group for drafting during the tenth year. From the critical ratio we may believe the facts to be fairly positive. The chances are 99.3 cases out of 100 that if the

Table VIII

Comparison of the Gains
of the Groups for the Test in its Entirety

Gains	Control Group	Experimental Group
55-59	0	2
50-	0	0
45-	0	3
40-	2	1
35-	5	6
30-	3	4
25-	4	6
20-	4	1
15-	5	3
10-	3	3
5-	2	0
0-	2	2
-5-	2	0
Total	32	32
Mean Gain	21.9	30.0
Standard Deviation	12.75	13.5
Standard Deviation of the Mean	2.26	2.39

Standard Deviation of the Difference of the Means	3.29
Critical Ratio	2.46

experiment were repeated the experimental group would again gain more than the control.[1]

6. Results of the tests on terms and tools. -- After determining gains and reliability of those gains for the test in its entirety, it is fully as important to study the parts of the test in the same manner to determine if any of the tests show value for traditional or experimental methods.

Table IX (page 39) indicates gains for the tests on terms and tools. This part of the test was too short to give a very valid result. It probably was somewhat too simple since several in each group received perfect scores and many scores were high, thereby reducing the amount of gain. The critical ratio indicates no reliable difference between the groups.

7. The comparison of the groups by recognition of views and patterns. -- The second test was created to determine how well pupils could visualize side views and patterns by studying front and top views. The results are shown in Table X (page 40).

Not only was the observed difference (.375) between the groups negligible, but also the gain in the ability to determine the appearance of the side views or patterns was very small.

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(1) Garrett, Statistics in Psychology and Education, page 134

Table IX

Comparison of the Groups
by Gains for the Tests on Terms and Tools

Gains	Control Group Pupils	Experimental Group Pupils
6-7	3	4
4-	5	8
2-	15	10
0-	8	10
-2-	1	0
Total	32	32
Mean Gain	3.06	3.38
Standard Deviation	1.95	2.02
Standard Deviation of the Mean	.34	.36

Standard Deviation of the Difference of the Means	.49
Critical Ratio	.65

Table X

Comparison of the Groups by Gains
for the Test on the Recognition of Views and Patterns

Gains	Control Group Pupils	Experimental Group Pupils
9-10	0	1
8-	0	0
7-	2	2
6-	2	3
5-	3	3
4-	3	5
3-	5	2
2-	5	3
1-	3	3
0-	0	3
-1-	5	3
-2-	2	1
-3-	1	2
-4-	0	1
-5-	1	0
Total	32	32
Mean Gain	2.5	2.875
Standard Deviation	2.96	3.39
Standard Deviation of the Mean	.52	.60

Standard Deviation of the Difference of the Means	.79
Critical Ratio	.47

8. <u>The comparison of gains for locating points and lines in views and patterns.</u> -- One of the most important factors in reading drawings is the ability to locate points and lines in any view and to realize whether lines are true length or fore-shortened.

Table XI (page 42) indicates how the groups varied in this ability. It appears from this test that the groups vary somewhat in this ability with a fairly definite indication that the experimental classes became more proficient in reading details on the drawings.

One interesting factor is that a few pupils of the experimental group improved noticeably above any of the control group. This was the factor which caused the greater standard deviation.

9. <u>Comparison of the two groups by drawing an original problem</u>. -- This test (see Appendix No. 10) was to determine gains in ability to do original problems. Probably this would indicate drafting ability rather than reading ability. The results are shown in Table XII (page 43).

The results of this test seem to show some gain in the experimental group over the control group when drawing an original problem. However the amount of gain is not great nor can it be said to be definite.

Table XI

Comparison of the Groups by
Gains for the Test on the Recognition
of Points and Lines in Views and Patterns

Gains	Control Group Pupils	Experimental Group Pupils
20-22	0	1
18-	0	0
16-	0	1
14-	0	0
12-	0	5
10-	4	3
8-	4	7
6-	10	2
4-	4	5
2-	3	2
0-	4	5
-2-	3	1
Total	32	32
Mean Gain	5.63	7.75
Standard Deviation	3.62	5.08
Standard Deviation of the Mean	.64	.89
	Standard Deviation of the Difference of the Means	1.09
	Critical Ratio	1.95

Table XII

Comparison of the Groups by Gains
Shown by the Test in Drawing an Original Problem

Gains	Control Group Pupils	Experimental Group Pupils
39-41	1	0
36-	0	0
33-	0	2
30-	0	2
27-	1	3
24-	2	3
21-	4	6
18-	5	2
15-	4	1
12-	4	1
9-	0	2
6-	0	2
3-	7	4
0-	1	0
-3-	0	2
-6-	2	1
-9-	0	0
-12-	0	0
-15-	1	0
-18-	0	1
Total	32	32
Main Gain	13.68	16.5
Standard Deviation	10.98	12.5
Standard Deviation of the Mean	1.94	2.2
Standard Deviation of the Difference of the Means		2.93
Critical Ratio		.96

10. <u>Comparison of the groups relative to gains in technique in drawing.</u> -- Pupils performed this test by copying a technical sketch which had been blueprinted (see Appendix No. 11).

There was a tendency to believe that with less actual work to perform on each plate and an increase in the number of plates it might cause pupils to sacrifice appearance for speed resulting in the loss of technique.

Table XIII (page 45) shows the results of this test.

The observed difference of the means favors the experimental group, but is significant not in the difference but in the fact that technique is not lost in doing workbook or completion type of drawing, at least in one semester.

Table XIII

Comparison of the Groups
by Gains Shown in a Test to Indicate Technique

Gains	Control Group Pupils	Experimental Group Pupils
6-7	0	2
5-	2	0
4-	1	0
3-	1	2
2-	5	4
1-	3	6
0-	6	4
-1-	9	8
-2-	2	1
-3-	2	3
-4-	1	0
Total	32	32
Mean Gain	.77	.91
Standard Deviation	2.04	2.13
Standard Deviation of the Mean	.36	.38
Standard Deviation of the Difference of the Means		.52
Critical Ratio		.27

11. <u>A summary of the gains of the groups as shown by the results of the tests</u>. -- In order to compare the results of the tests as shown in the last six tables more conveniently, a summary of the factors has been made in Table XIV (page 47).

The evident results of the tests are as follows:

a. There is value shown in the workbook type of drawing.

b. All comparisons made in the study showed gains for the workbook over the traditional method.

c. The greatest value shows in the ability to locate definite points and lines on any views or patterns.

d. Judging from the distribution of gains certain types of pupils seem to learn noticeably more from the workbook type than others for the standard deviations were greater and the spread was toward the upper level of ability. The lower level of ability seemed to be very similar for both groups in each test.

e. The least improvement was indicated in tests of drawing, technique abilities, and determining the appearances of views and patterns from key views.

Table XIV

The Results of the Tests
as Shown in Tables VIII to XIII

Table	Test	Group	Mean	S.D.	M	D	C.R.
VIII	Entire test	C	21.9	12.75	2.26	3.29	2.46
		E	30.0	13.5	2.39		
IX	Terms-Tools	C	3.06	1.95	.34	.49	.65
		E	3.38	2.02	.36		
X	Views and Patterns	C	2.25	2.96	.52	.79	.47
		E	2.87	3.39	.60		
XI	Points and Lines	C	5.63	3.62	.64	1.09	1.95
		E	7.75	5.08	.89		
XII	Drawing	C	13.68	10.98	1.94	2.93	.96
		E	16.5	12.5	2.2		
XIII	Technique	C	.77	2.04	.36	.52	.27
		E	.91	2.13	.38		

Key

C------Control Group
E------Experimental Group
Mean--Average gain determined from tests
S.D.--Standard Deviation
M------Standard Error
D------Standard Deviation of the Difference of the Averages
C.R.--Critical Ratio

THE EFFECT OF THE

WORKBOOK METHOD ON PUPILS OF VARYING

DRAFTSMANSHIP ABILITIES

Chapter VI

The Effect of the Workbook Method on Pupils of Varying Draftsmanship Abilities.

Supplementary to the more statistically accurate data regarding this experiment were other factors of merit that should be recorded to give a complete description of the results. One of these factors is the reaction such a course has on pupils of various stages of drafting ability.

1. Results of the workbook course for varying draftsmanship-ability groups. -- Since Mechanical Drawing or Engineering Drawing in the public school should be taught more from the standpoint of reading ability than drafting ability, the test should indicate a similar amount of improvement for the poor, average and excellent draftsmanship groups. The previous two semester grades were obtained for each pupil of both the Experimental and Control Groups. These grades should indicate draftsmanship-ability because the work consisted of the type of work that would create proficiency with drafting tools and the elementary features of Industrial Drawing.

2. Results shown by the study of the tests according to draftsmanship-abilities. -- Table XV shows the Control and Experimental Groups subdivided into Ability Groups determined by class grades awarded previously to the experimental semester's work. The average gain for

each ability group was determined for the battery of tests and the difference in gains for Experimental Group over the Control Group indicated.

It is obvious that the average ability pupils of the Experimental Group increased their gain in knowledge over a like group in the Control Group by an amount quite equal to the more fortunately endowed pupil. Even pupils of little draftsmanship ability show substantial gains for the Experimental Group over the Control Group.

Table XV

Comparison of the Gains for the Control and Experimental Sections According to Ability Groups.

Ability Group	Av. Gain for Control	Av. Gain for Experimental	Difference
D--Poor	26.8	32.7	5.9
C--Poor to Average	18.4	26.4	8.0
B--Fairly Good	31.2	34.8	3.6
A--Outstanding	21.2	29.8	8.6

Total points in the test -- 123

3. Effect of the course on final grades for the semester. -- From the preceding paragraphs and table it

might be expected that the grades of the Experimental Group would be higher than those of the Control Group and also show an increase in grade status over the previous two semester's work. However, according to the study made and indicated in Table XVI such is not the case. In fact the table indicates the opposite trend.

Table XVI

A Comparison of the
Frequencies of Recorded Grades
for the Experimental and Control Groups
Before and at the Close of the Experimental-Semester

Control Group			Experimental Group	
Av. Grade Mech. Dr. I & II	Grade for Mech.Dr.III (Exp.Sem.)	Grade	Grade for Mech.Dr.III (Exp.Sem.)	Av. Grade Mech. Dr. I & II
*	3.7%	E	6.0%	*
12.5%	16.7	D	16.0	12.5%
37.5	26.0	C	30.0	37.5
34.4	39.0	B	26.0	34.4
6.2	14.8	A	10.0	6.2

Note: Compare each column with a normal frequency distribution.

* There could be only special cases where failing students would be permitted to progress to the next higher grade of class work.

4. <u>General observations from Table XVI</u>. -- The first point to note is that the grades of the pupils appearing for classes in which the experiment was made were almost indentical as shown previously in Chapter IV dealing with the selection of pupils. One may note, however, that the distribution is skewed toward the higher grades. A comparison of grades at the end of the test-semester shows that the Control Group accents this tendency while the Experimental Group tends a little more toward a normal distribution. This indicates that the greater number and the form of the plates for the Experimental Group gives the instructor more opportunity to appraise a pupil's work than the traditional method.

5. <u>Conclusions from observing the ability and class grade tendencies</u>. -- This phase of the study shows that the workbook method of teaching Engineering Drawing is as beneficial for the average pupil as the pupil that has unusual drafting abilities. There are indications that it allows the instructor better opportunities for judging each pupil's knowledge of Industrial Drawing and of dealing with individual differences in ability.

ATTITUDE OF THE PUPILS TOWARD THE EXPERIMENTAL COURSE

Chapter VII

Attitude of the Pupils
Toward the Experimental Course

Information that can be calculated on a mathematical basis according to rules of statistics is definite but not necessarily complete. There are factors that cannot be measured accurately but are important. It is for this reason that a questionnaire was given to each pupil of the Experimental Group at the end of the semester.

1. The questionnaire. -- A questionnaire of seven parts, as shown in the Appendix No. 12, was given to each pupil of the Experimental Group. It was simple and as short as possible to insure spontaneous answers. Its purpose was to determine the general attitude of the pupils toward the workbook method for instruction in fundamentals of drafting.

2. The method of administering the questionnaire. -- In order to obtain as unbiased answers as possible the questionnaire was not given until the pupils knew that all semester grades were delivered to the office. The answer sheets did not require the names of the pupils and they were encouraged to answer only those questions that they felt could be answered definitely.

Forty-nine of fifty-eight questionnaires were returned. The returns from the questionnaire will be found in the following paragraph.

3. <u>Results tabulated from the questionnaire to determine attitude toward the experimental method.</u> --

Question	Reason for Asking the Question	Results
1. From what you remember of Drawing I & II do you prefer making 35 or more plates?		37--Yes 6--No 6--Indifferent
2. If your answer was Yes, was it because		
a. No borders to lay out?		41
b. Less lettering?		43
c. Less layout; less chance of starting incorrectly?		47
d. Other reasons.		3--Less time wasted 2--Speed in finishing plates.
3. Do you feel that by making complete plates you would have a better appearing set?	Most boys keep the plates they make to show drafting ability when getting a job.	38 felt this set as valuable as others. II felt the other way was better.
4. Did inaccuracies of printing create a feeling of carelessness in appearance or accuracy?	During the printing process circles printed slightly elliptical and angles were not accurate.	22--Yes 17--No 10--Indifferent

Question	Reason for Asking the Question	Results
5. Did boys in other classes wish they were in your class?	Pupils in other teachers' classes were aware of the experiment as well as the control group.	34 answered, but only 12 were definite answers. 7 knew boys that wished they could be in the experimental class. 5 had noted boys saying it seemed like a lot of work.
6. What other points not already mentioned did you like about this course?		9--"Less waste of time starting" 8--"Less opportunity of starting incorrectly" 2--"Looked better when finished" 2--"Chance to do more kinds of problems" 2--"There seemed to be a continuity" 2--"Liked getting to the problem with very little time for demonstration"
7. What things about the course did you not like?		2--"Inaccuracies on the sheets" 3--"Printed lines didn't match in color values" 3--"New plates came so fast we didn't understand clearly" 1--"Some drawings were not clear as to what was required"

It is interesting to note that some of the class kept rather close check on the other classes to suggest "it showed more continuity" and there was a "chance to do more kinds of work." This last statement was not quite true for there were no more different kinds of work but rather more variations of the same kinds.

After studying the answers to the questions it seems that whatever was antagonistic could be corrected with practice and care, while most of the class were quite certain it was an improvement over the old method of doing the complete plate.

Finally, it is worthwhile noting that so many pupils were as enthusiastic as is indicated when this particular semester's unit is considered to be one of the most uninteresting and difficult of the six semesters required at Technical High School.

CONCLUSIONS,

LIMITATIONS AND OBSERVATIONS

Chapter VIII

Conclusions, Limitations and Observations.

At this particular time it is not only necessary to teach basic information, but also, to teach as much specific information as possible in order to prepare our younger generation for the industrial world in which they must compete.

Many of the older methods of teaching fundamentals were thorough and excellent, but now certain specific industrial information must be included. With class periods shortened and new subjects crowding into the curriculum the necessary time to teach both phases seems almost impossible. To omit either is poor pedagogy. This study of the workbook method of teaching drafting and blueprint reading was made in the hope of improving the course for more complete mastery in quality and quantity.

After careful experimentation for one semester certain statements of results can be made.

1. Statistical conclusions obtained from the experiment. -- Considering the experiment in terms of accepted educational statistical practice the following deductions may be expressed:

a. Conclusions from using the test in its entirety were based upon two groups of 32 cases which were carefully selected to secure an equality of ability. The experimental group indicated an average observed gain of 8.1 points in a test of 123 total points or about a 6.6% gain over the traditional method.

By statistical predictions the reliability of this gain is 2.46 standard deviations greater than zero or 142 chances to one to show improvement over the control group.[1] While this gain shown is not great and the reliability, though fairly high, is not decisive, it does indicate that there is merit in the practice which should be sifted from this method of teaching by further study and experimentation.

b. Upon considering the results for each particular phase of the test, one finds that the phase having to do with careful analysis of each line and point was outstanding. (See test for Recognition of Points and Lines, Appendix No. 9 and Table XI page 42. Such ability is fundamental for any reader of blueprints. Since the number of readers is many times greater than the number of draftsmen, this one factor in teaching is worthy of careful study.

The other phases all showed small gains for the experimental group, but the measures of reliability were too low to indicate that there was definite value over the older method of instruction.

c. While no questionnaire has the validity of the careful and unbiased report of the statistical problem, there are some salient facts that can be noted which would

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(1) Tiegs and Crawford, Statistics for Teachers, Chapter IX page 137.

not otherwise be considered.

(1) Pupils indicated a preference for short problems over long, drawn-out ones.

(2) There was also an almost unanimous preference for plates with much of the lettering done and border lines completed.

(3) Some of the less noticeable, but very important, factors were a saving of time, less errors, better looking finished products, less lecturing and explanation, and more applications or variations studied.

2. Limitations of the experiment. -- As in all problems certain limitations are bound to appear.

a. The most natural limitation is the fact that an experimental method is usually a new method without the benefit of the practice, the conveniences, and the refinements of the traditional methods.

b. The number of cases should be greater. Two groups, one following the experimental course and another the older method, of only 32 pupils each is not adequate for statistical significance. These groups would have been larger had it not been for the number of pupils leaving school to take advantage of high wages in war industries.

c. The course of work and tests had to be compiled without benefit of tested validity. The experiment was formed for an intermediate class where pupils were required to have prescribed training before advancing to the following semester's work within the drafting curriculum in this particular school.

d. The process for printing the plates was comparatively new and the results were hardly professional, so that the plates contained inaccuracies which caused some dissatisfaction in instruction.

3. <u>Some observations relative to the experiment in general</u>. -- In the conduction of such an experiment as this certain facts are observed which have little to do with statistical data, but are important to the adoption of any new methods.

a. There was a noticeable amount of enthusiasm for the workbook method by the pupil. This was probably due to the fact that units of work were completed in much less time than in the traditional method and, therefore, did not become uninteresting. If sheets were spoiled due to errors or inaccuracies, new ones were given for repeating the problems. Pupils seldom objected to redrawing plates in the experimental group, whereas, with the traditional group this practice often caused discouragement because it meant the loss of several class periods or else time after school to catch up with the class requirement.

Examples of good lining, lettering, and dimensioning on the workbook sheet served as an incentive to some pupils to do better work.

Pupils liked the idea of a "starter" which saved the responsibility of plotting. This process did save time, but may have been impractical. No doubt further study in the preparation of the plates might have provided for some practice in plotting.

A very few pupils did seem overwhelmed by the number of plates and the speed with which new ones appeared, but two pupils who were repeating the course because of failure the previous semester were comparatively enthusiastic with their accomplishment of the greater amount of assigned work and their ability to grasp facts that previously were meaningless.

Pupils prefer to work rather than to listen to lectures. The experimental units were sufficiently short so that only a few minutes of explanation or demonstration were necessary and there were no long series of directions to forget. The layout allowed immediate practice of the explanation; no preliminary work was necessary.

b. From the teacher angle there were some disadvantages which were offset by certain advantages.

The method did make a greater number of plates to check and grade. Also, it was necessary to return the plates as soon as possible for reference for the following problems. However, with a transparent key-plate these sheets were very rapidly checked since in most cases there were but two or three factors to consider. The grading was reduced to more objectivity and with twelve plates required for the marking period instead of the usual three or four, grading was much more satisfactory to both student and teacher.

With shorter demonstration periods there was considerably less duplication of explanation to individuals and more time to watch and direct effort.

The experimental course simplified the problem of supplying the requirements for the slow and rapid individuals by assigning the essential plates as required work and others as supplementary problems. This, also, allowed better opportunities for testing within marking periods.

It would seem that any teacher using the workbook system of teaching mechanical drawing would find that the simplicity of the classroom organization, the more satisfactory results in grading, and the release from repeated explanation more than compensate for the greater number of plates to handle and the extra bookkeeping in recording grades.

c. The measure of a school's success is its ability to supply trained youth for gainful occupation or further education. Usually any method or device which will better prepare the pupils is acceptable to the administrative officers if the material cost does not conflict with the budget items and the method does not molest other school plans or developments.

The workbook system would tend to standardize the mechanical drawing courses from semester to semester and between teachers which is a good feature if instructors do not let it become entirely "frozen" to improvement of its problems, or fail to correlate with kindred courses.

The actual cost of using the workbook system is variable depending upon several factors. If the work sheets must be bought and supplied to the pupils the cost per pupil for materials would be comparatively expensive. If there are facilities to make the plates within the school and pupil help can be used, then the actual additional cost will be only equal to the extra paper used. Stencils can be permanent equipment to be used as necessary. Economies, such as printing on both sides of the sheet, can be practiced.

In systems where pupils supply their equipment and materials the commercially printed plates would seem to be most satisfactory.

To adopt such a course as a permanent system depends, therefore, on the school organization and its facilities for printing or duplicating the sheets.

4. General conclusions. -- A final conclusion indicates there are apparently positive values and some limitations to teach drafting by the use of the workbook or work sheets.

The advantages are: It can be made an orderly course that could be standardized within the school so that kindred subjects may correlate with it. The class organization is simplified for teaching processes and the grading is more objective. Pupils can complete more problems within a unit of time than by the traditional method. All indications point to as good if not better results than the traditional course in pupil development in drafting ability and knowledge.

The limitations observed are: The method is more expensive for supplying materials. Care must be exercised or the course may become static. Its use does not save work for the teacher. Not all phases of drafting would be satisfactorily taught by this method.

Just how much value there is in each of the advantages is not possible to determine because means for measuring them accurately are not obtainable as yet or because they are not mensurable. However, there was enough positive evidence indicated to warrant more careful study of this device which tends toward mastery of the language universally used in the industrial world.

APPENDICES

Appendix 1

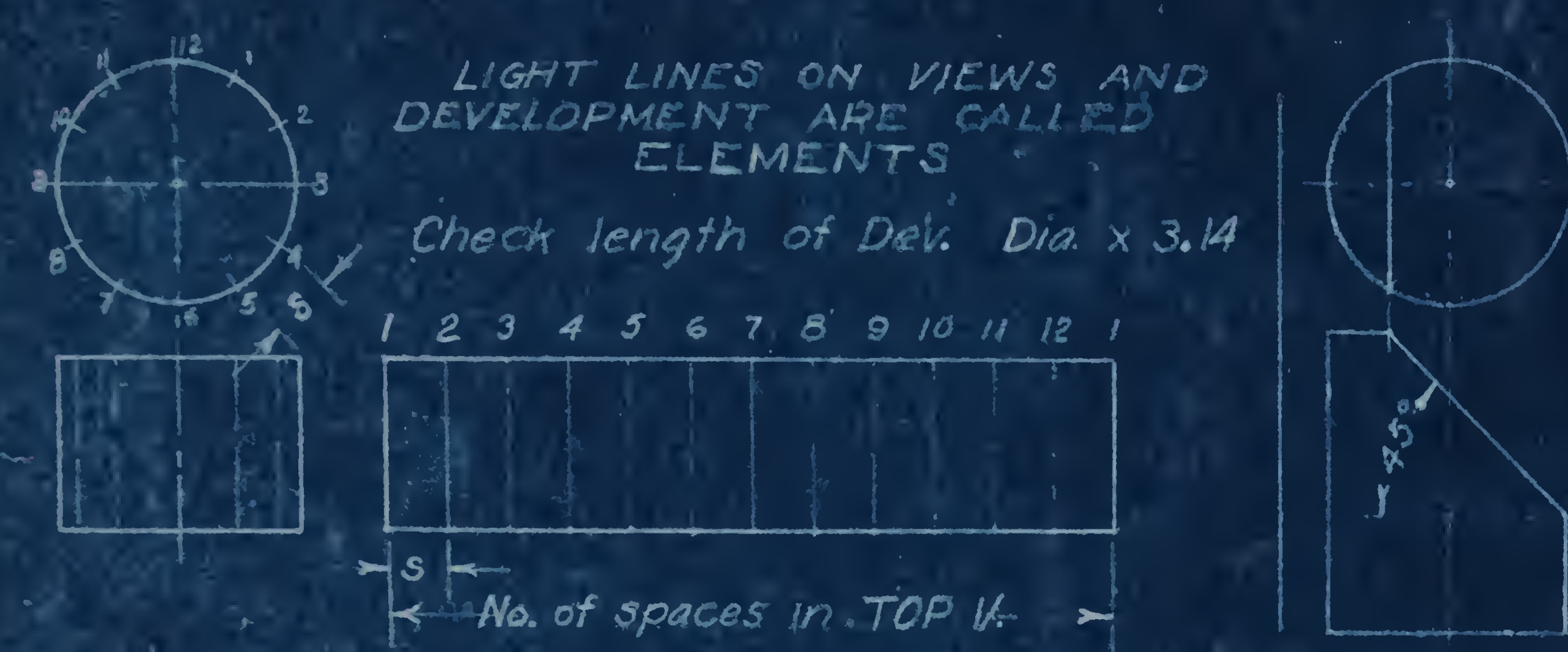
Prints Used for Problems Nos. 3, 8, 9 and 12 in the Control Group

The following three prints indicate how problems were presented to the Control Group. Fifteen such problems were issued to the pupil either separately or in bulletin form for solution during the semester.

The course required the pupil to recreate or develop the front, top, profile and auxiliary views with the surface development for such abstract objects as truncated prisms, cones, cylinders, pyramids and intersecting prisms and cylinders.

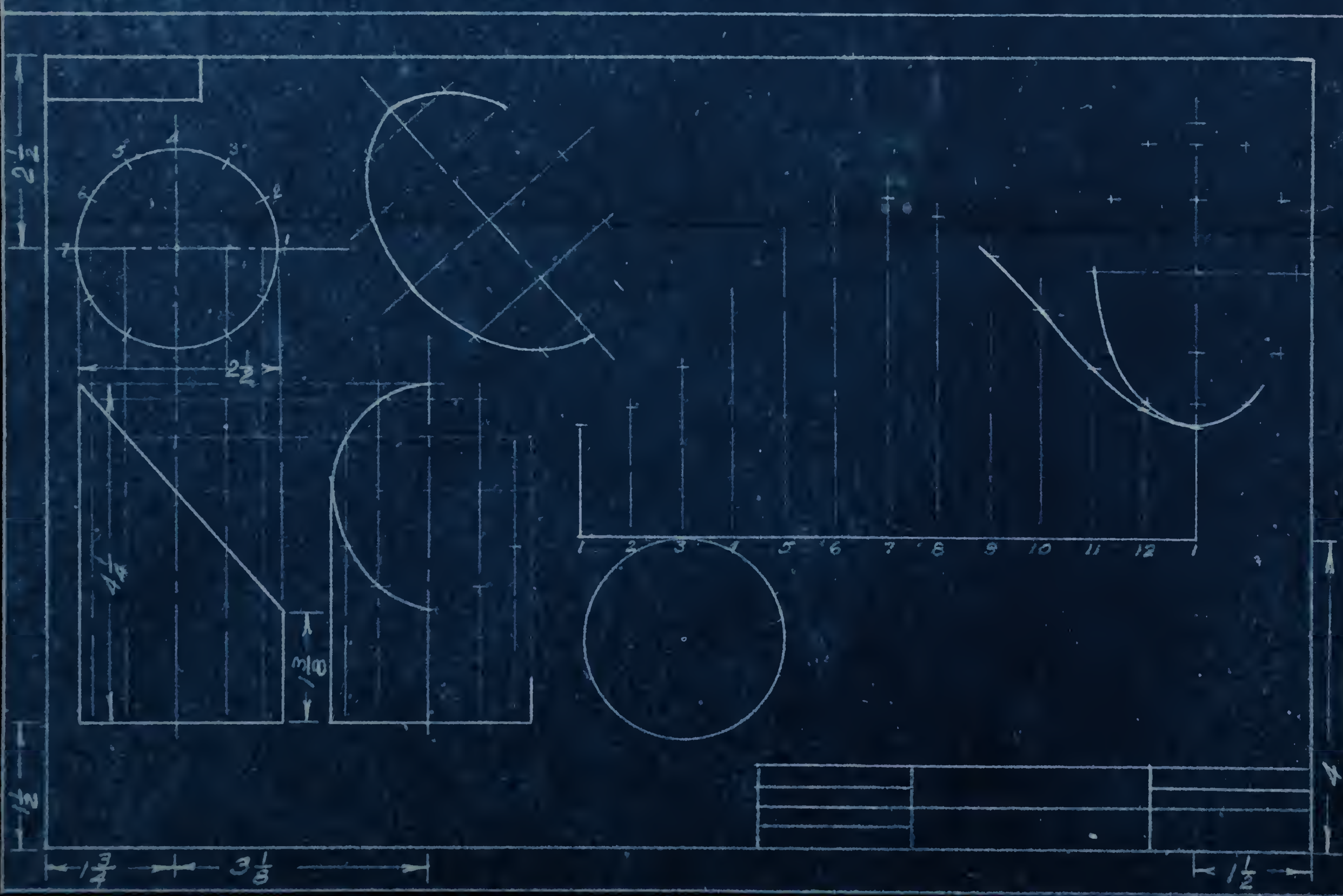
PROBLEM: Draw the F, T, RS, A and Development of the Truncated Cylinder. The construction will be very similiar to the Hex. Prism except for 12 "sides" instead of 6 and the points must be connected with the French or irregular curve. Be sure to read page 27 in your text about the use of the curve before you start. It will be worthwhile to trace the points through onto a piece of scrap tracing paper to experiment and practice on before drawing curves on your regular plate.

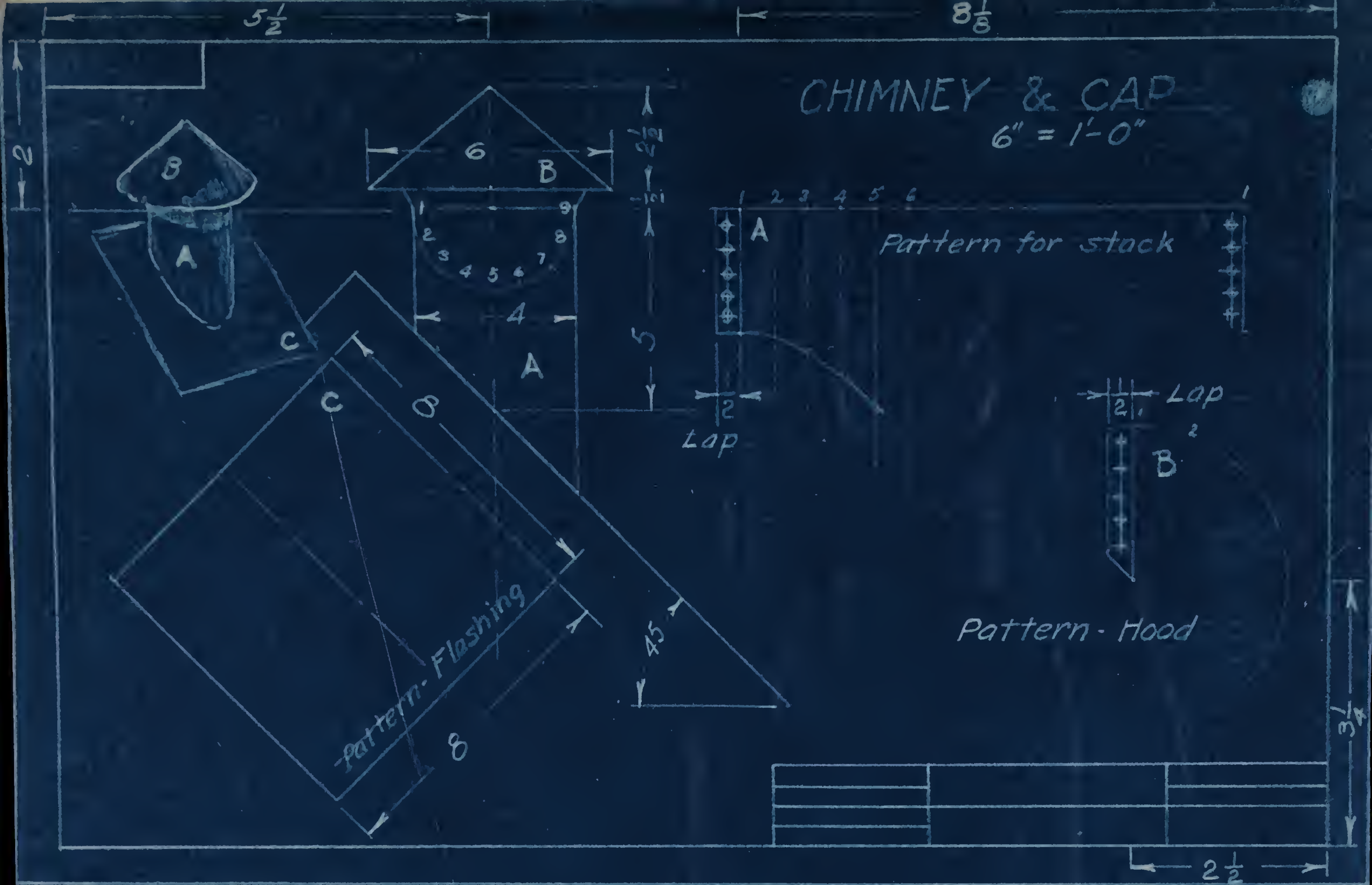
Don't forget to number the points on all the views.



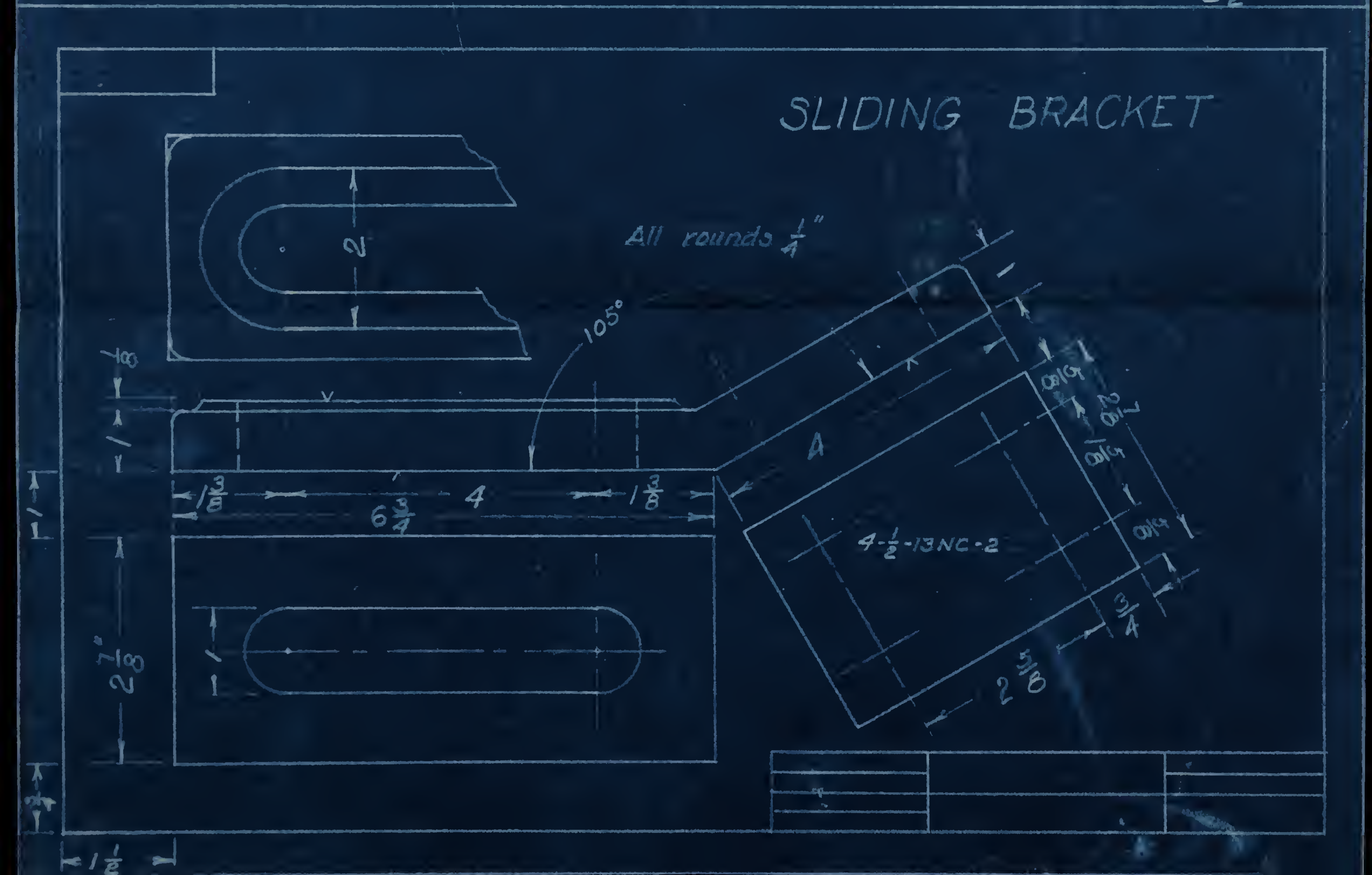
Special Problem

Use the same layout and dimensions as on the regular plate



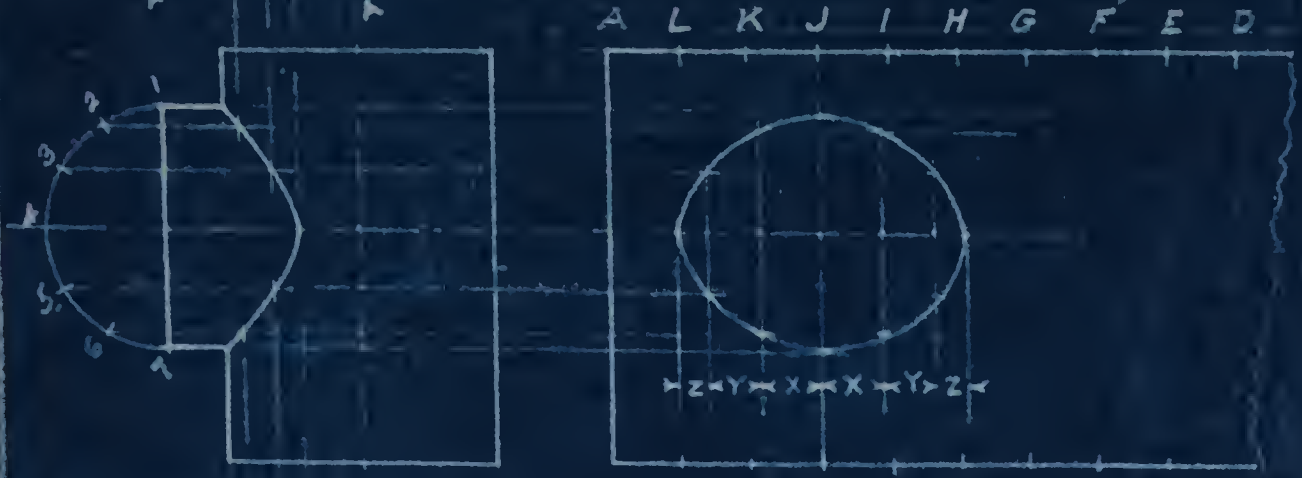


CHIMNEY & CAP
6" = 1'-0"
Pattern for stack
Pattern - Hood
Pattern - Flashing
Lap

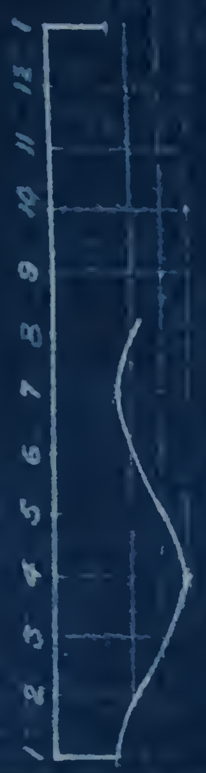


SLIDING BRACKET
All rounds $\frac{1}{4}$"
105°
4-$\frac{1}{2}$-13NC-2

PROBLEM: Draw the intersecting cylinders and develop a pattern for each part.



The example shown has been drawn according to the sheetmetal worker's method. Only half of the top view has been drawn. The half circle on the front view and the quarter circle on the top view take the place of a side view.



The patterns have been developed directly from the front view. This method saves time but not space. It does show quite clearly how the patterns are created.

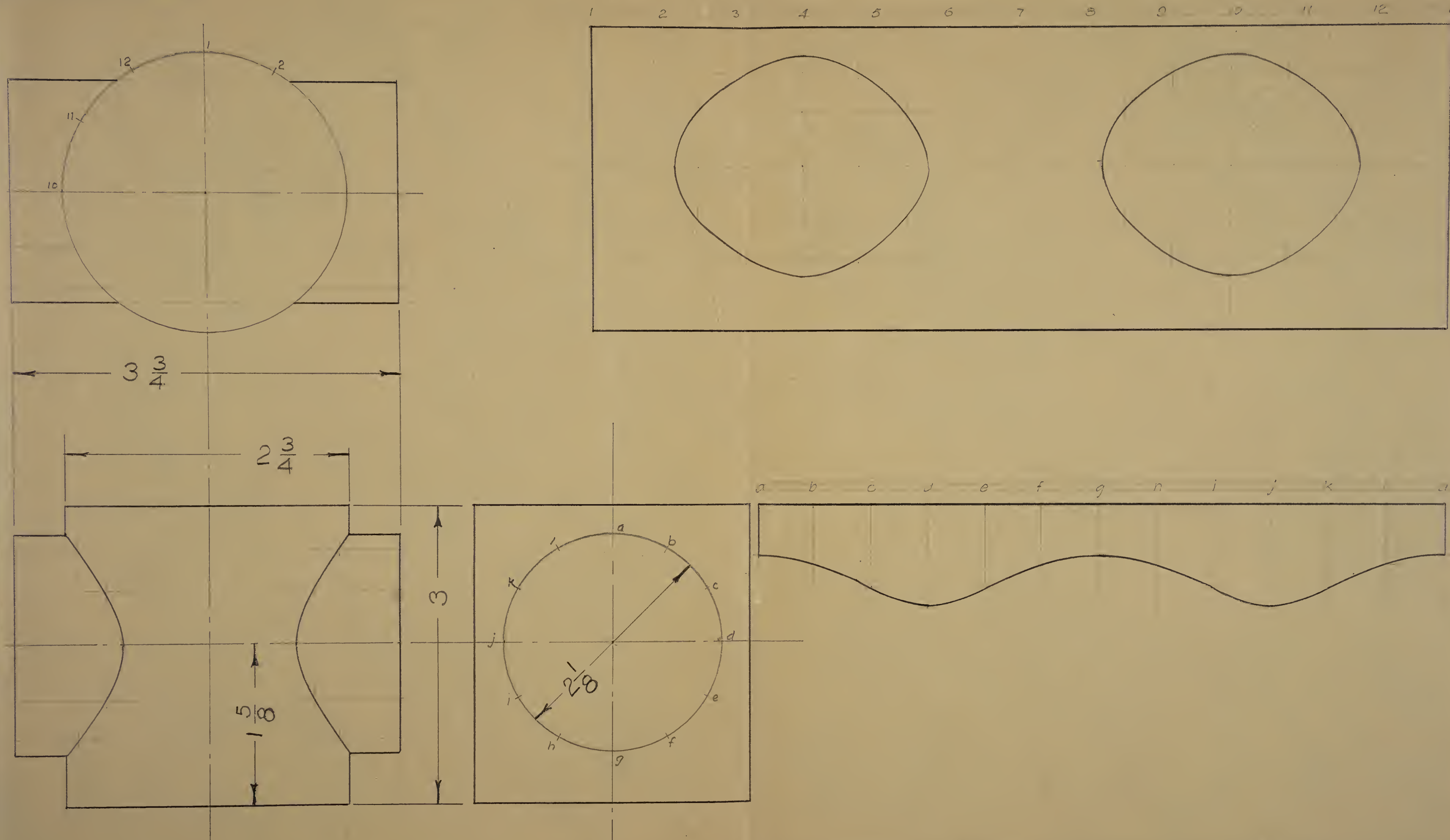
Notice that the hole in the larger pattern is an ellipse. Space X, Y and Z with the dividers. Transfer the X space first; add to it the Y space and finally the Z space. <u>It must be done that way</u>. Why?

Appendix 2

A Student's Drawing

of Problem No. 12 in the Control Group

B-12



SCALE FULL	INTERSECT. CYLINDERS	CK'D. BY
DATE 10/12/41		BEN. 6 PER. 1
DR. BY	TECHNICAL HIGH SCHOOL	B-12
TR. BY	SPRINGFIELD, MASS.	

Appendix 3

The Preparation of the Units for the Experimental Group

The pupils in the Control Group were supplied seventeen problems with their bulletin, but the average boy would only be able to complete eleven or twelve of them. The course for the Experimental Group would necessarily contain about forty problems so that no one project would last more than three class periods and some of them would be finished in one period.

Two of the best known workbooks or sets of work sheets were examined as material for this course, but they were not accepted as satisfactory for the experiment or fair to the pupil because they contained other phases of drafting than the fundamentals of projection. Also, these courses did not contain the problems that had been developed in the traditional course for the Control Group and therefore, would not be a fair test of the process. Furthermore, these classes do this work in preparing for upper class work and should not deviate too far from the original course. It was, therefore, necessary to develop an entirely new set of plates based on the traditional course of fundamentals and covering all material taught in the control group. Any extra plates added to the course were repetitions with variations or were preliminary steps to a new problem.

After developing the course the plates were redrawn with proper ink on "DupliMAT" stencils procured from the Addressograph-Multigraph Company. These stencils were used to print, by an offset process, onto 9 x 12 sheets of buff detail paper by means of the "Multilith Duplicator". Students in the Office Service Department of the school performed the actual printing.

The process was comparatively new so that the results were not professional, however, there was a noticeable improvement in making the stencil and printing as the sequence progressed.

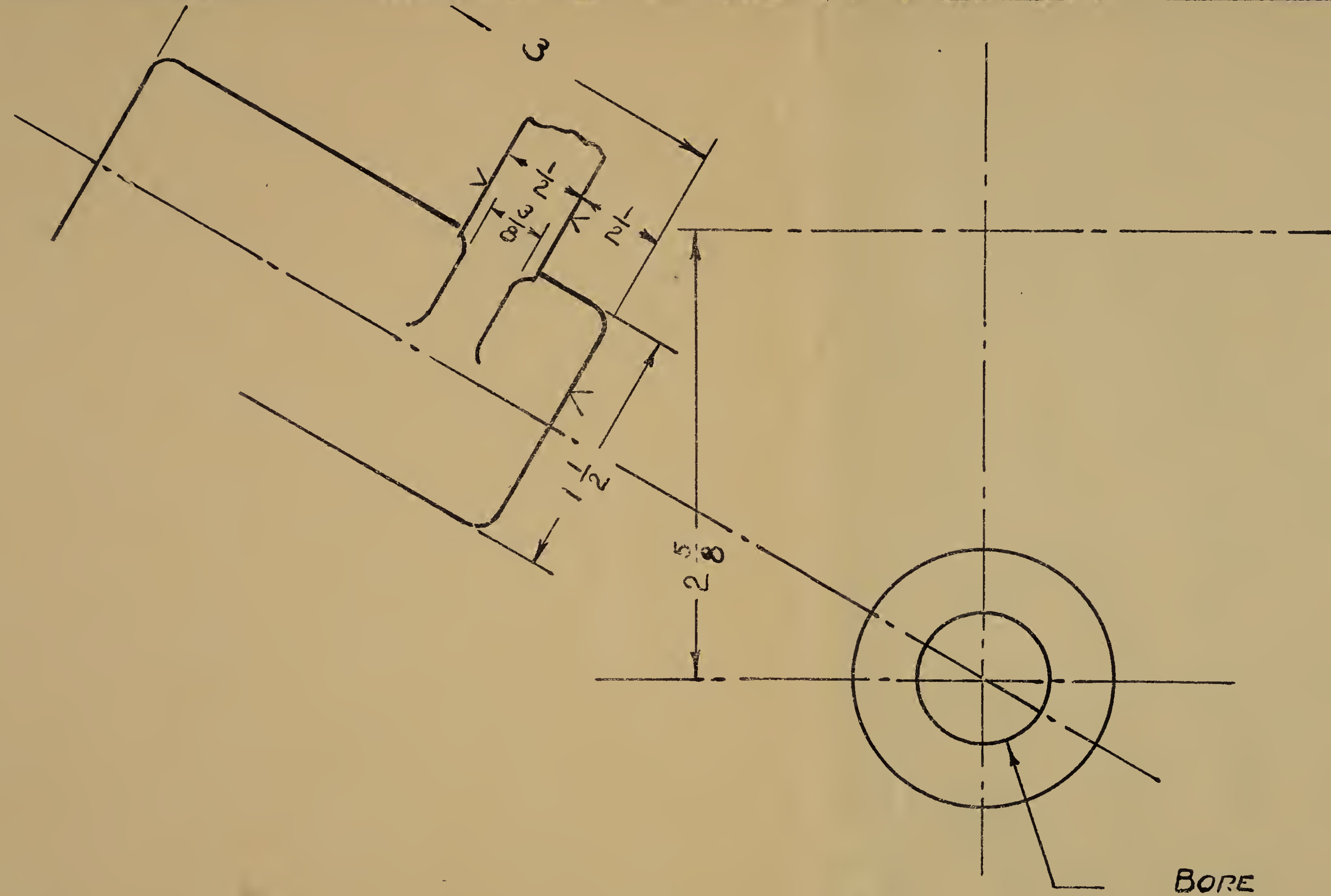
Appendix 4

Plates Used for Problems

Nos. 3, 19 and 36 in the Experimental Group

The following four sheets indicate the form of the plates that the pupils received in the Experimental Group. Forty plates were issued. Some problems were abstract, many were more practical and developed in the sheetmetal workman's method.

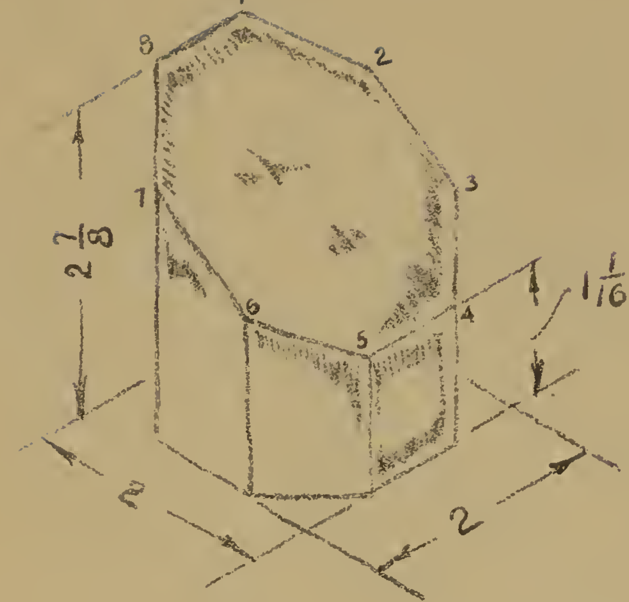
No more units were taught than in the Control Group. The plates, in this form, however, allowed considerable expanding of each unit.



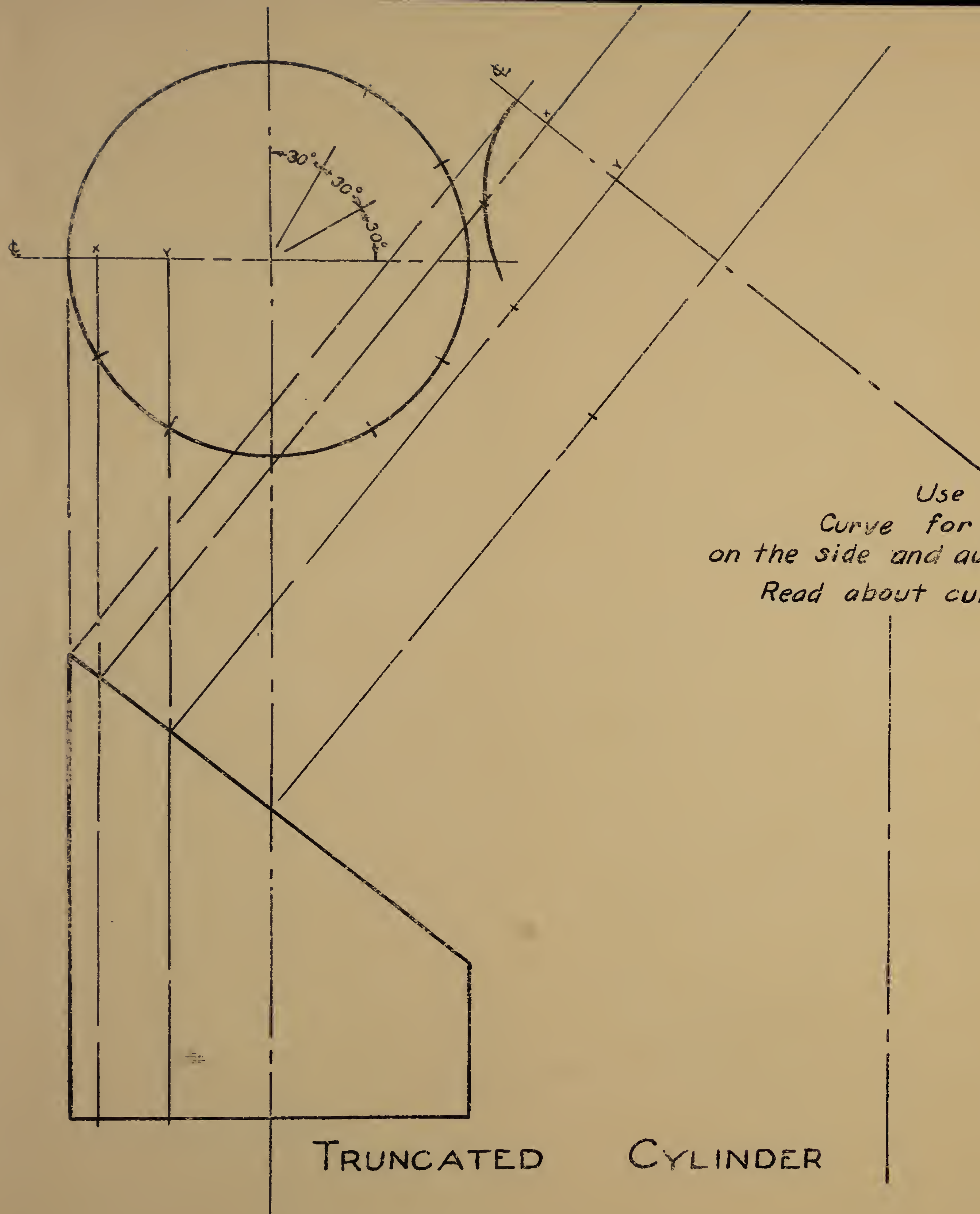
Complete front and auxiliary views. Dimension.

See page 194 in your text.

SCALE		CK. BY
DATE		BENCH PERIOD
DR. BY	TECHNICAL HIGH SCHOOL	
TR. BY	SPRINGFIELD, MASS.	

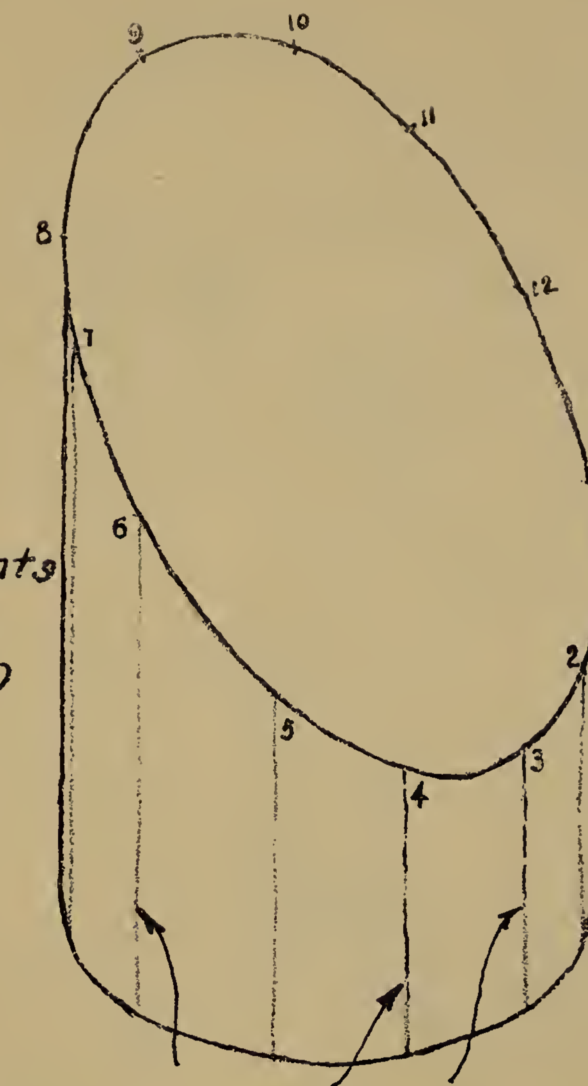


NAME ____________ BENCH ______ PERIOD ______



Use an Irregular Curve for connecting points on the side and auxiliary views

Read about curves. Text p. 40

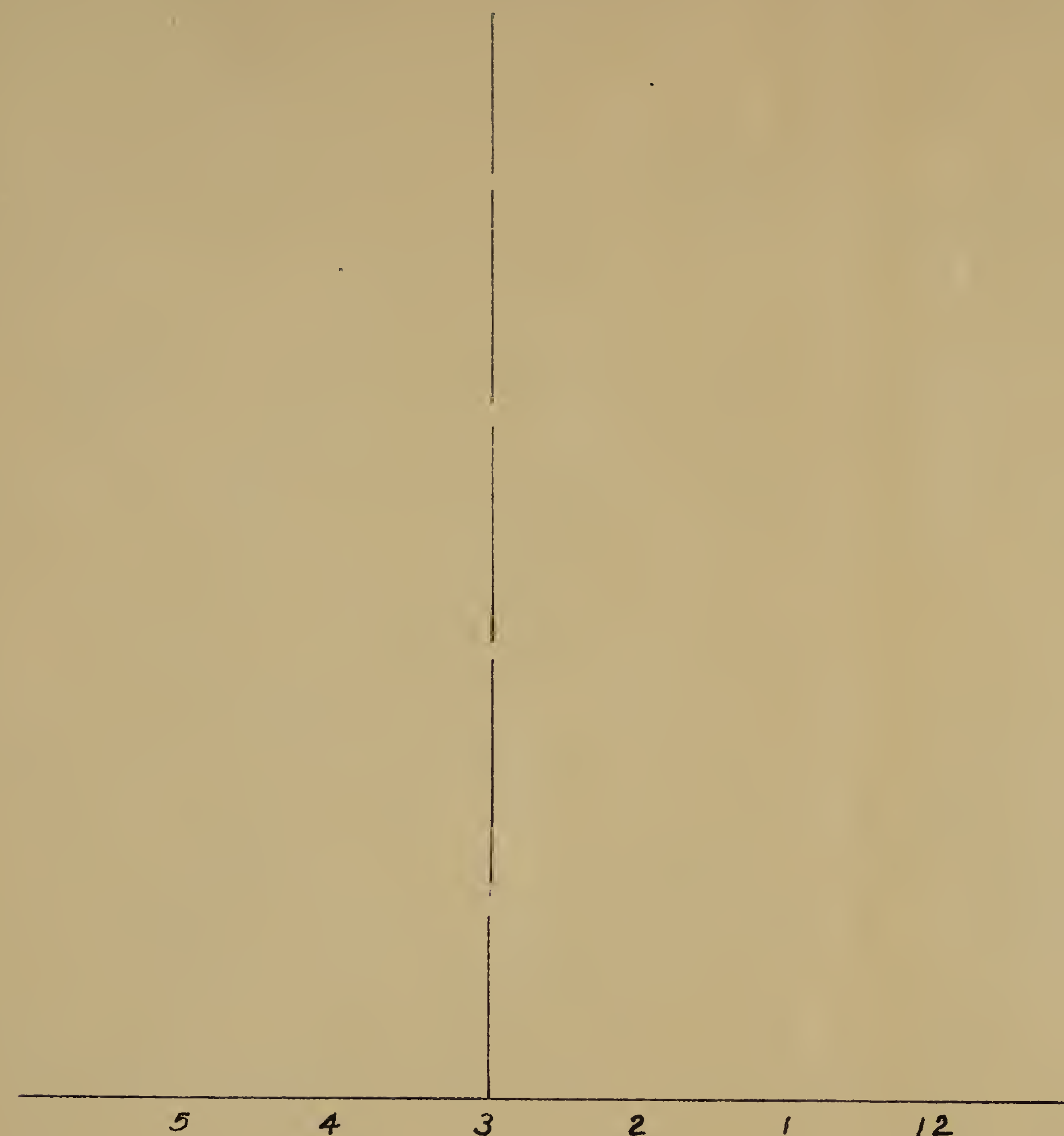


These lines represent edges and are called ELEMENTS

Number the elements according to the picture on all four views.

TRUNCATED CYLINDER

NAME BENCH PERIOD



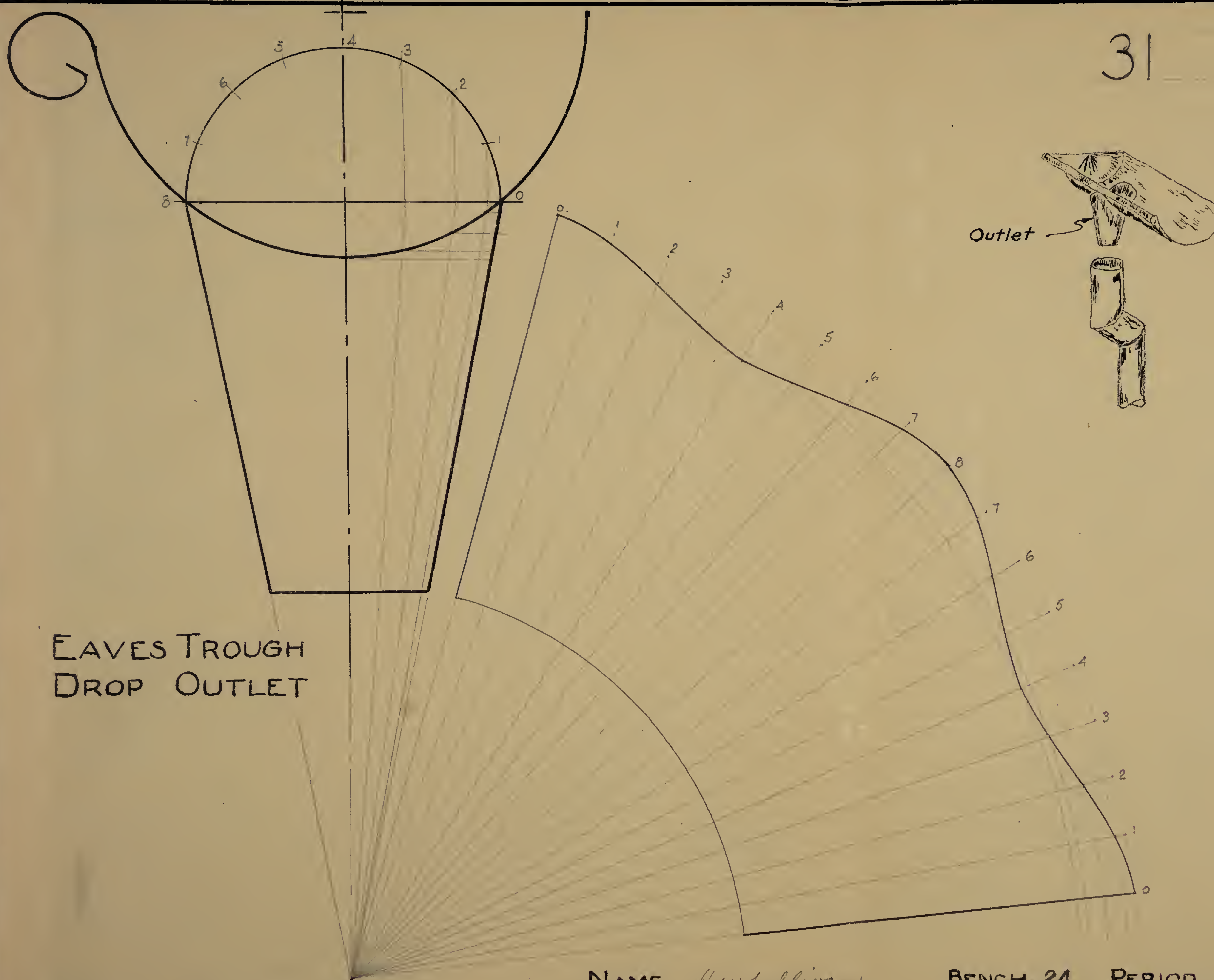
PATTERN FOR THE
TRUNCATED CYLINDER

NAME BENCH PERIOD

Appendix 5

A Student's Drawing

of Problem No. 31 in Experimental Group



EAVES TROUGH DROP OUTLET

NAME H.W. Sullivan BENCH 24 PERIOD 3

Appendix 6

Terms and Tools Test

Drawing III Test No. 1

Choose the best word or phrase from the list to complete each sentence. Place its letter in the parenthesis before the statement.

You will have 7 minutes to complete the test.

( ) 1. A plane, flat surface bounded by 6 sides is ____.

( ) 2. A line that is drawn to represent an imaginary edge is ____.

( ) 3. A line that is true-length in the front view appears as ____ line in the top view.

( ) 4. A solid having two bases (top and bottom) and sides whose edges are parallel is ____.

( ) 5. In order to draw the pattern of an object it is necessary to find ____ of each edge of element.

( ) 6. ____ is the name of a tool to divide a line or space into a number of equal parts.

( ) 7. A common, round tin can has the form of ____.

( ) 8. A line that is neither horizontal nor straight up and down is ____.

( ) 9. A solid that has a base and a number of sides which meet at one point is ____.

( )10. To determine the exact shape of a slanting surface of an object it may be practical to make ____.

A. cylinder
B. dividers
C. octagon
D. compass
F. altitude
G. vertical
H. prism
J. true-length
K. perspective view
L. element
M. horizontal
N. hexagon
O. pyramid
P. bottom view
Q. oblique
R. auxiliary view

Name ______________________ Bench ____________ Period ____

Appendix 7

Terms and Tools Test

Drawing III Test No. 2

(Answer form for the following test.)

1. ________

2. ________

3. ________

4. ________

5. ________

6. ________

7. ________

8. ________

9. ________

10. ________

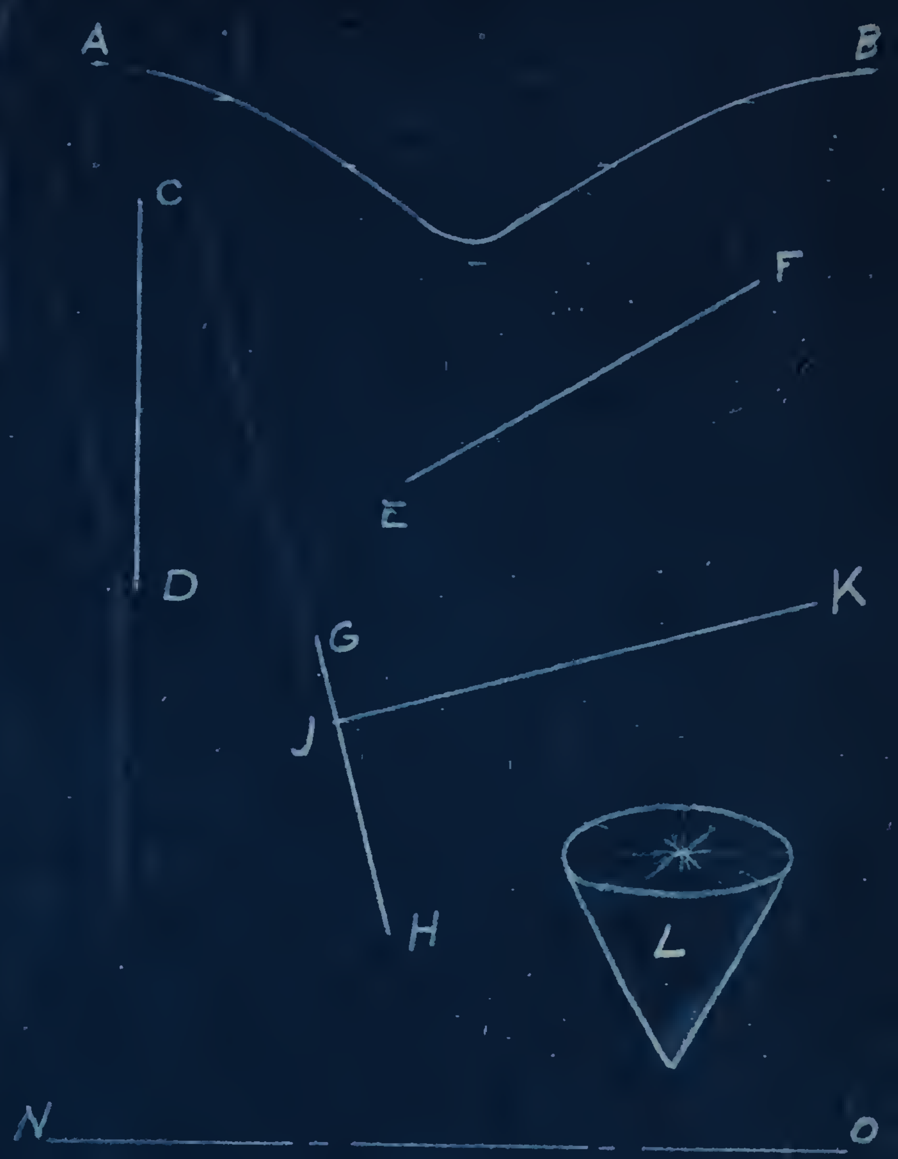
Name ______________________ Bench _______ Period _____

DRAWING III TEST No. 2

Choose the best answer from the list to complete the sentence and put its letter after the proper number on your answer sheet.

You will have 12 minutes to complete the test.

1. The line AB would be drawn with ______.
2. The line CD is ______.
3. Line EF is ______.
4. Line JK is ______ to GH.
5. The figure indicated by L is ______.
6. The distance M is called ______.
7. Line NO is ______.
8. The top of the figure indicated by Q is ______.
9. When pattern R is folded so that edge ao meets co it will make ______.
10. The surface indicated by S is called ______.



A. oblique
B. center line
C. oblong circle
D. auxiliary
E. cone
F. pentagonal
G. irregular curve
H. perpendicular
J. foreshortened
K. compass
L. altitude
M. ellipse
N. vertical
O. pyramid

Appendix 8

Views and Development Test

Drawing III Test No. 3

On the blueprint are side views, auxiliary views and developments numbered 1 to 15. Each of the fifteen belong to one of the drawings marked with letters outside of the double line. Indicate which of the lettered drawings each numbered view or development belongs.

1. ______	9. ______
2. ______	10. ______
3. ______	11. ______
4. ______	12. ______
5. ______	13. ______
6. ______	14. ______
7. ______	15. ______
8. ______	

Name ____________________ Bench _______ Period _______


A
B
C
D
E
F
1.
2
3
4
5
6
7
8
9
10
11
12
13
14
15
G
H

Appendix 9

Location of Lines and Points

Drawing III Test No. 4

Part 1. Location of points on the views.

1.	Point A	on the	picture	is	___	on	the	top view.
2.	" 33	" "	front view	"	___	"	"	side view.
3.	" L	" "	picture	"	___	"	"	top view.
4.	" L	" "	picture	"	___	"	"	development.
5.	" 62	" "	side view	"	___	"	"	front view.
6.	" R	" "	picture	"	___	"	"	front view.
7.	" R	" "	picture	"	___	"	"	auxiliary view.
8.	Line MN	" "	picture	"	___	"	"	front view.
9.	" CB	" "	picture	"	___	"	"	side view.
10.	" 1-9	" "	top view	"	___	"	"	front view.

Part 2. Indicate on the blanks if the lines mentioned are true-length, foreshortened or construction. Use a "T" for true-length, "F" for foreshortened, "C" for construction and "DK" for don't know.

1. Line 10-11	_____	6. Line 58-59	_____
2. " 32-33	_____	7. " 22-25	_____
3. " 20-25	_____	8. " 70-71	_____
4. " 9-10	_____	9. " 21-33	_____
5. " 37-38	_____	10. " 22-39	_____

Test No. 4 continued

Part 3. Selection of lines or distances for forming a development.

1. To obtain line 69-70 on the development measure _____-_____

2. " " " 67-71 on the development measure _____-_____

3. " " " 72-85 on the development measure _____-_____

4. " " " 74-83 on the development measure _____-_____

5. " " " 67-70 on the development measure _____-_____

6. " " " 67-87 on the development measure _____-_____

7. " " " 70-71 on the development measure _____-_____

8. " " " 74-75 on the development measure _____-_____

9. " " " 91-95 on the development measure _____-_____

10. " " " 68-87 on the development measure _____-_____

Name ________________________ Bench _______ Period _____

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
37 38 39 40 41 42 43 44 45 46 47 48 49
50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66
67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
A B C D E F G J L M N P Q R S T U V

Appendix 10

Drawing Problem

Drawing III Test No. 5

The following test was used for determining drawing ability. The grading of this test was based on the correct formation of the views and development of the pattern as called for on the print.

The score was developed as follows:

Maximum points for plate--46

Subtract one point for

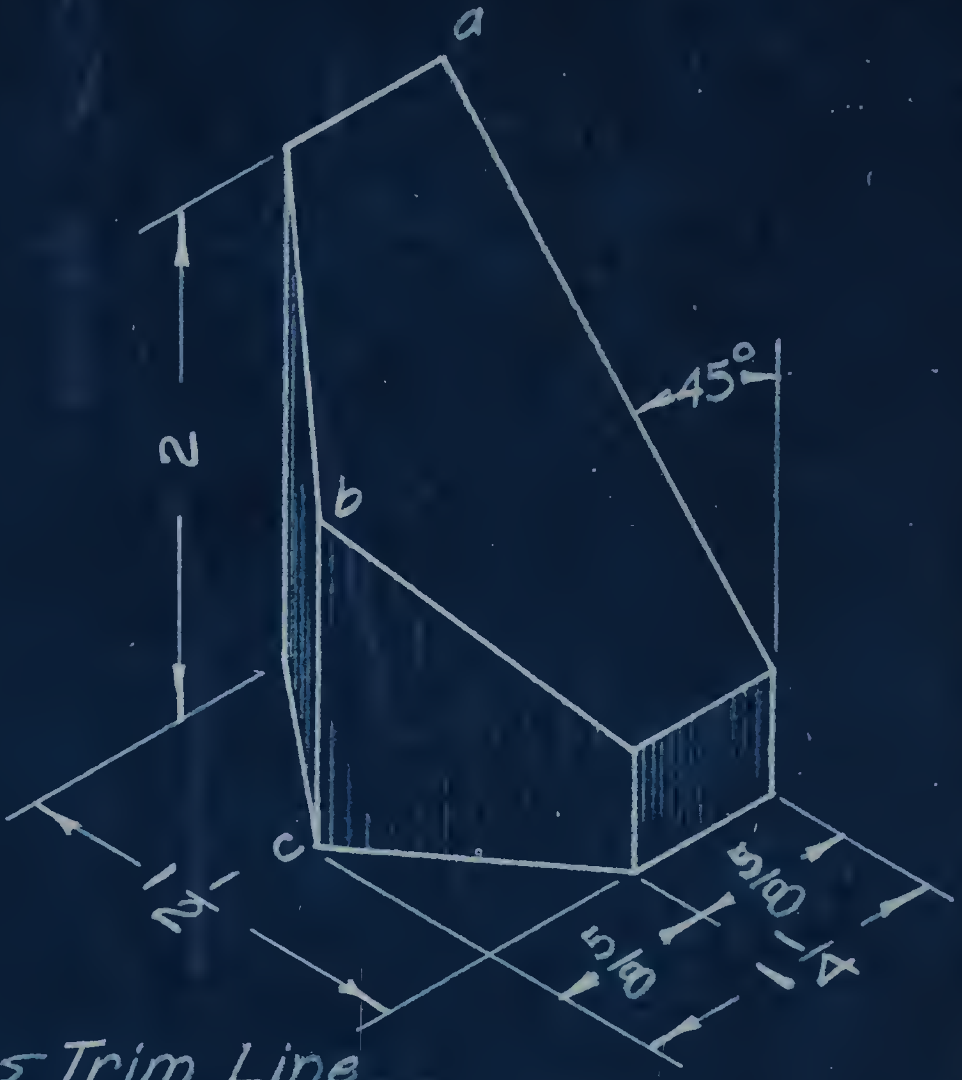
a. Each line omitted on the drawing.

b. Each surface omitted or out of place on the development.

c. Each corner letter omitted or out of place.

Subtract five points for

a. Each view omitted or out of place on the drawing.



Make a complete drawing of the object pictured above. Layout the plate as illustrated.

The drawing will include (1) front view (2) top view (3) right side view (4) auxiliary view (5) development.

Use full scale. Dimension. Indicate on all views including the development the points or corners marked a, b, and c in the picture.

You will have 35 minutes. It is important that you block out as much of the drawing as you can. Don't "clean-up" or retrace until the views are all blocked in and the points marked. Be accurate.

Appendix 11

Drawing Test for Technique

Drawing III Test No. 6

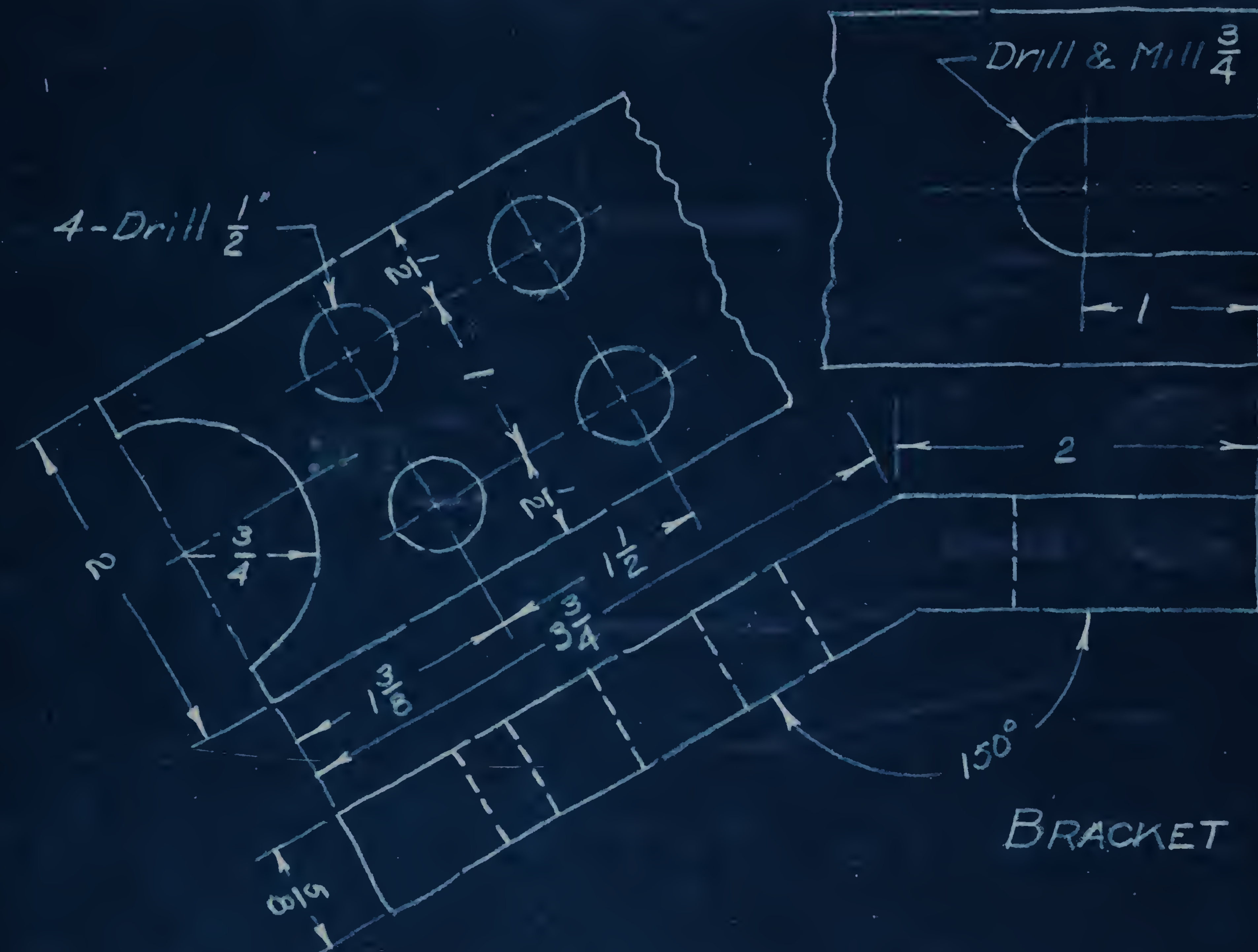
This test was scored entirely on accuracy, lining, lettering and layout. Time was not considered.

Each plate was graded for one item at a time and awarded three points if excellent, two if average, and one if poor. The process was then repeated for each of the other items.

The items were as follows:

1. Accuracy of measurement (checked with a tracing).
2. Line value (weight, "run-overs", consistancy in length of dashes or spaces in invisible outline and extension lines).
3. Lettering (according to the American Standard Association model).
4. Plotting (general appearance and balance of plate).

Make as neat a drawing as you can from the sketch of this detail. Use approximately the same locations of views, dimensions and notes. Ask for help if you find any part you do not understand. 30 min.



Appendix 12

Questionnaire for Mechanical Drawing III

Note: Do not write your name on this questionnaire.

1. From what you remember of Mechanical Drawing I & II, do you prefer making thirty-five or more plates as you did for Mechanical Drawing III? ____________________

2. If your answer to question No. 1 was "yes" was it because

   a. No borders to layout? ______________

   b. Less lettering? ____________________

   c. Less layout, less chance of starting incorrectly? ____________________

   d. Other reasons? ____________________

   ____

3. Do you feel that by making complete plates you would have a better appearing set? ____________

4. Did inaccuracies of printing on the plates create a feeling of carelessness in appearance and accuracy in your work? ____________________

5. Did boys in other classes of Drawing III wish that they were in your class because of the different method of drawing? ____________________

6. What other points not already mentioned did you like about this course? ____________________

7. What was there about the course that you did not like? ______________________________

Appendix 13

Example of Method for Determining Statistical Data

Table VIII

Comparison of the Gains
of the Groups for the Test in its entirety

Gains	Control Group Pupils				Experimental Group Pupils			
	f	d	fd	fd^2	f	d	fd	fd^2
55-59	0	7			2	7	14	98
50-	0	6			0	6		
45-	0	5			3	5	15	75
40-	2	4	8	32	1	4	4	16
35-	5	3	15	45	6	3	18	54
30-	3	2	6	12	4	2	8	16
25-	4	1	4	4	6	1	6	6
20-	4				1			
15-	5	-1	-5	5	3	-1	-3	3
10-	3	-2	-6	12	3	-2	-6	12
5-	2	-3	-6	18	0	-3		
0-	2	-4	-8	32	2	-4	-8	32
-5-	2	-5	-10	50	2	-4		
Total	32		-4	210	32		48	312

$$\text{Mean or Average} = \text{Guessed Average} + \frac{fd}{N} \cdot \text{interval}$$

$$M = 22.5 + -4/32 \cdot 5 = 21.9$$
(Mean for Control Group)

$$M = 22.5 + 48/32 \cdot 5 = 30.0$$
(Mean for Experimental Group)

$$\text{Standard Deviation} = \left[\sqrt{\frac{fd^2}{N} - \left(\frac{fd}{N}\right)^2}\right] i$$

$$S\ D = \left[\sqrt{\frac{210}{32} - \left(\frac{-4}{32}\right)^2}\right] 5 = 12.75 = \text{S D for the Control Group}$$

$$S\ D = \left[\sqrt{\frac{312}{32} - \left(\frac{48}{32}\right)^2}\right] 5 = 13.5 = \text{S D for the Experimental Group}$$

This standard deviation is a measure of dispersion of cases and when measured above and below the average on the normal curve it indicates roughly the middle 2/3 of the range. Thus, the dispersion of cases of the range is slightly greater for the Experimental Group.

In order to determine the reliability of the mean in educational statistics it is customary to compute the standard error of the mean.

$$\underset{(\epsilon_M)}{\text{Standard Error}} = \frac{\text{Standard Deviation}}{\sqrt{N}}$$

$$\epsilon_M = \frac{12.75}{\sqrt{32}} = 2.26 \qquad \epsilon_M = \frac{13.5}{\sqrt{32}} = 2.39$$

(Control Group) (Experimental Group)

This indicates that the chances are 2 to 1 that the true mean lies somewhere within 2.26 points either way from the found mean of the Control Group.

For the Experimental Group the chances are 2 to 1 that the true average is 2.39 points on either side of the determined mean of 30.0.

The difference between the averages for the Control Group and Experimental Group is 8.1 points (30.0 - 21.9) in favor of the Experimental Group. To determine the reliability of this difference it is customary to use the following formula:

$$\text{Standard Deviation of the Difference of the Means} = \sqrt{\underset{\text{(Control)}}{\epsilon_M{}^2} + \underset{\text{(Exper.)}}{\epsilon_M{}^2}}$$

$$\epsilon_D = \sqrt{2.26^2 + 2.39^2} = 3.29$$

This indicates that in 68 cases out of a 100 the true difference of the averages will fall within the actual difference (8.1) $\pm$ 3.29.

Determining the critical ratio or the number of ϵ_D units above zero:

$$\text{Critical Ratio} = \frac{\text{Actual Difference}}{\epsilon_D}$$

$$= \frac{8.1}{3.29} = 2.46 \ \epsilon_D \text{ units.}$$

Referring to the tables [1] this factor indicates 99.20 cases out of 100 or 144 chances to 1, the Experimental group will show better results than the Control Group using the same materials and tests.

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(1) Tiegs and Crawford, Statistics for Teachers, p. 137

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